

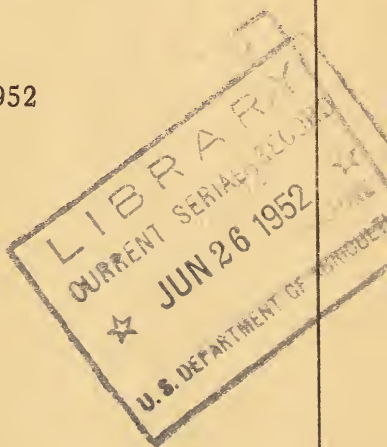
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UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
OFFICE OF EXPERIMENT STATIONS

REPORT ON
THE AGRICULTURAL EXPERIMENT
STATIONS, 1951

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OFFICE OF EXPERIMENT STATIONS

AGRICULTURAL RESEARCH ADMINISTRATION

B. T. SHAW, *Administrator*

OFFICE OF EXPERIMENT STATIONS

R. W. TRULLINGER, *Chief*

E. C. ELTING, *Associate Chief*

H. C. KNOBLAUCH, *Assistant Chief*

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WALWORTH BROWN, *Administrative Officer.*

DWIGHT L. ESPE, *Experiment Station Administrator—Dairy Husbandman.*

NOLAN F. FARRIS, *Experiment Station Administrator—Agronomist.*

FRED D. FROMME, *Research Coordinator.*

WILLARD H. GARMAN, *Experiment Station Administrator—Soil Technologist.*

JAMES O. GRANDSTAFF, *Experiment Station Administrator—Animal Husbandman.*

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CHRISTINE JUSTIN, *Home Economist.*

CAMILLE L. LEFEBVRE, *Experiment Station Administrator—Plant Pathologist.*

DAVID V. LUMSDEN, *Experiment Station Administrator—Horticulturist.*

EDWARD R. MCGOVAN, *Experiment Station Administrator—Entomologist.*

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RALPH B. NESTLER, *Experiment Station Administrator—Poultry Husbandman.*

BARTON C. REYNOLDS, *Experiment Station Administrator—Agricultural Engineer.*

GLENN R. SMITH, *Experiment Station Administrator—Marketing Technologist.*

HENRY M. STEECE, *Experiment Station Administrator—Agronomist.*

WHITNEY B. STOUT, *Experiment Station Administrator—Marketing Technician.*

JOSEPH W. WELLINGTON, *Experiment Station Administrator—Horticulturist.*

FEDERAL EXPERIMENT STATION IN PUERTO RICO (P. O., MAYAGUEZ)

Kenneth A. Bartlett, *Director*

Arnaud J. Loustalot, *Assistant Director*

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1951¹

By R. W. TRULLINGER, *Chief, Office of Experiment Stations*, in collaboration with the technical staff

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STATION RESEARCH STRENGTHENS SECURITY

The American worker in agriculture has a much higher productive efficiency than agricultural workers in most other countries. This is revealed by recent information on the amount of work time required in the United States and 19 foreign countries to buy an equivalent amount of food items.²

In 1951 less than 20 percent of American people lived on farms, but each farm worker fed himself and 14 other individuals. That this was possible represents an important economic achievement. For 1951 was a year of expanding urban employment and incomes, a year of unprecedented industrial activity stimulated by the Nation's will to gird its security through a program of all-out production. Full production in industry demands that workers have abundance of energy-giving food at fair prices. Greater numbers of men in the Armed Forces make it necessary that we have increasing supplies of top-grade food and wearing materials for our servicemen. America's industrial and military power are, therefore, closely associated with its agricultural production efficiency.

¹ Submitted in accordance with the requirement that the Secretary of Agriculture shall report to Congress on the work and expenditures of the State agricultural experiment stations established under the Hatch Act of 1887 and supplementary legislation. The period covered is the fiscal year ended June 30, 1951.

² Kravis, Irving B. Work time required to buy food, 1937-50. U. S. Bur. Labor Statis., Monthly Labor Rev. 72:143-151. 1951.

Credit for the high degree of farm efficiency the Nation has attained goes rightfully to the workers on American farms. They have worked hard and intelligently to reach high-level production. But credit must also be given to the scientific men at State agricultural experiment stations and in the United States Department of Agriculture. They comprise the technical force that works for the solution of a continuous stream of problems confronting farm producers. They engage in many research activities, basic to agriculture, which are aimed at solving immediate production problems under a wide variety of soil and weather conditions in the several States and Territories. These include much fundamental research, the results of which are essential to the advances of agricultural technology and in turn to human welfare.

Together with their colleagues of the cooperative extension service, the research men in agriculture place at the public disposal a service through which farm families are able to convert scientific knowledge into practice. In close association with industry, which supplies the mechanical power for modern farming, the fertilizers, the chemicals, and many other essentials for production efficiency, the research and extension workers of our State agricultural colleges and the Department of Agriculture are the force that stands behind the American farmer in his successful endeavor to create abundance. Money spent for agricultural research at the experiment stations and in Department research agencies brings financial returns not only to agricultural producers, but to the public as a whole. Measured in terms of what it has contributed to farmers' incomes, to the process of making available abundant food supplies, and to the national security, the annual returns from research far outweigh its cost.

Now we are in a state of national emergency in which a high production of food and clothing is probably more important than ever before in our history. The United States population now exceeds 155,000,000. During the years 1940 to 1950 it increased at the rate of 2,000,000 annually. During 1951 the average increase was 7,400 per day. This rapidly increasing population must be fed and clothed, and we have little additional land from which to get food and fiber. Only through research can we meet this situation on the same number of acres.

MARKETING AND DISTRIBUTING AGRICULTURAL PRODUCTS

Over the years experiment station research has greatly stepped up farm production through the application of science. Farm production and the distribution of agricultural products are so closely tied together in our free enterprise economy that an experiment station could hardly carry on research in one without becoming involved in the other. Furthermore, research in both fields in proper balance is essential to promoting progress in a balanced agricultural economy. This report will endeavor to present some of the high lights of the results of research aimed at solving problems in the marketing and distribution of farm products.

Marketing research is probably as important during the present emergency as ever before in our history. With a rapidly increasing population and no immediate prospect of increasing the acreage of

agriculturally productive land, it is of utmost importance to make the most of present production of food and fiber by getting these products where they are most needed in the best of usable condition, and with a minimum of loss through spoilage and mishandling.

As evidence of what research has accomplished in enhancing the ability to produce, it is significant that estimates by the Bureau of Agricultural Economics place the physical volume of agricultural production in the United States in 1950 at four and one-half times that of 1870. Not until after production reached a high point during and after the First World War did it become obvious that there could be overproduction and underconsumption, that such relationships could bring surpluses, and that uncontrolled surpluses could bring low prices and depression. With the immediate emergency past farmers had no sound basis to produce unless they were able to find satisfactory markets. For this reason marketing research and its application began in earnest in the 1920's at the State experiment stations. The Purnell Act of 1925 emphasized research in agricultural marketing and economics among other things, and the Research and Marketing Act of 1946 gave special emphasis to marketing research, service, and education. These two acts stimulated a broad program of research in marketing and distribution at the experiment stations. Special provisions were made in the Research and Marketing Act for regional cooperation among the stations, and for cooperation in marketing research between the experiment stations and the Department.

The agricultural marketing and distribution problems which science seeks to solve cover a wide range. They include problems on the assembling of products on the farm and in distributing them to purchasers at the point of consumption, or, where farm products serve as raw materials, to the industries; to homes, where agricultural fibers add to modern conveniences and comforts of living; and to the men, women, and children wearing the clothing into which agricultural fibers are woven. Other problems involve determining the facts on how and from where commodities move from producer to consumer and what factors enter into determining the price; which methods and procedures are most efficient in doing the job; how public services are aiding in the process; how costs and margins can be reduced without detracting from the services performed; how tariffs, Federal programs, interstate traffics, municipal laws, and regulations affect the sale of commodities; how local and area factors affect the sale of commodities whose production has become highly specialized; what consumer preferences are in various urban centers; what additional or improved facilities and equipment are needed and how they should be used in doing a more effective and economical job; how market losses and spoilage can be reduced; and how nutritive value and quality can be improved and preserved and losses prevented.

Whether we face an era of peace and plenty, a continued period of world tension, or the turmoil of war, research in the marketing of agricultural commodities along these several lines is a major function requiring the highest degree of scientific approach. Research in some of these lines of marketing are being conducted by all of the State experiment stations, either singly or in regional cooperative groups, as circumstances warrant.

Approximately 450 lines of marketing investigations are under way at the State experiment stations. The following report on the objectives and the procedures followed in these investigations, and some of the accomplishments achieved in a few of the projects under way, indicates the scope and extent of the broad research program at the stations aimed at keeping the marketing of agricultural products abreast of the current and prospective national need.

Competitive Position in Distribution

United States farmers, for one reason or another, constantly find themselves in competitive positions in the marketing and distribution of the food and fiber they produce. This competition may be local in nature; it may be between different producing areas in the same State; or it may be regional, interregional, or international in scope. Competitive problems may relate to kinds and quality of crops grown, costs involved, prices received, seasonality of production, transportation and market facilities, available handling practices and marketing methods, time in transit, and perishability of commodities in the marketing process. There may be other decisive factors which farmers, as individuals or groups, should be aware of before attempting large-scale production for market.

Interregional competition

The Storrs station (Connecticut) found that midwestern farmers enjoyed an advantage of about 1 cent per dozen in the production of eggs over Connecticut farmers, because of the differential transportation rates on feed and eggs. An analysis accordingly has been made of the important trends and factors that determine the size and nature of the egg-producing industry, which provides farmers with information on the kind and degree of future competition and the necessary steps to take in both production and marketing.

Studies by the Delaware station on interregional competition in the production and marketing of broilers showed that broiler production efficiency was about equal in all producing areas. The cost of production in Delaware was lower than in Georgia but about the same or slightly higher in other areas. Feed surplus areas such as Indiana had little cost advantage over Delaware. Higher retail sales margins on feed in feed surplus areas largely offset lower wholesale feed prices. Broiler-producing areas near markets have transportation cost advantages over more distant areas, but this advantage can be minimized by the distant areas through selling ready-to-cook broilers and using mechanically refrigerated trucks. Factors which helped in stabilizing the Delaware broiler industry were the early start made by the State in the industry, large-scale operations, nearness to markets, and the employment of a credit system which allows growers to shift risk of losses to financing agencies. The Delaware broiler industry appears to have a long-time production and marketing cost advantage in the East but can expect a gradual loss of more distant markets.

Data compiled from studies made by the New York (Cornell) station on the competition between potato-producing areas in the State made it possible for special marketing agreement committees to make decisions on a more scientific and equitable basis. The study grew out of the practice of automatically coupling marketing agreements with price supports. The station data furnished facts on the relative

yield and production of potatoes in competing producing areas, the distribution from these areas to the four leading markets for New York potatoes, the weekly seasonal movements of carlot shipments from competing areas, costs of handling, freight rates, and prices at the principal shipping points.

To enable peach growers in New Jersey to maintain their competitive position in the production and marketing of their fruit, the State station in cooperation with the United States Department of Agriculture³ undertook research that points to the need for greater care in picking, grading, and packing peaches. In 1949 and 1950, growers lost up to \$40 per acre through bruised fruit alone. It was found that about 10 percent of the peaches harvested were bruised in picking, grading, packing, and shipping. Damaged fruit ranged from almost none on some farms to more than 15 percent on others. On the basis of the study, peach growers in New Jersey are now being urged to follow a 10-point program to avoid bruising and consequent money losses and thereby improve the position of Jersey peaches in the competitive market.

The Wisconsin station has shown that commercial potato stocks from 15 States are competing with potatoes produced in southern Wisconsin. This area is potentially one of the best outlets for potatoes grown in the State, provided there is a steady supply of high-quality tubers. If Wisconsin growers want to meet out-of-State competition, the station suggests four possible approaches: (1) Continue research in plant breeding to develop better quality; (2) avoid dumping low-quality, locally grown potatoes on the market; (3) stress the importance of proper handling, transportation, and storage; and (4) develop more effective merchandising programs.

Consumer Demand, Preference, Acceptance

Attention has been centered in recent years on studies concerned with consumer demand, preference, and acceptance. Some of this research is being done by the experiment stations in cooperation with the Department, on a regional basis. Farmers feel that they need more information along these lines, especially in the case of certain fruits and vegetables, meats, dairy, and poultry products.

Size and color preference for potatoes

The Bureau of Agricultural Economics has shown that three-fifths of United States homemakers prefer a "medium size" potato for general use. Later, a North Central regional study sought to establish consumer definitions of "Small," "Medium," and "Large" potatoes in terms of actual size. In the Chicago market area, 2,840 homemakers were interviewed. Although their definitions varied somewhat at the upper and lower size limit, the median description placed Small potatoes at $2\frac{1}{4}$ inches in diameter; Medium at $2\frac{3}{4}$ inches; and Large at $3\frac{1}{4}$ inches.

Another phase of the same regional study showed that 80 percent of the customers questioned on the St. Louis market usually bought the same color of potatoes as those bought at the time of the interview and 69 percent gave their preference as either red or white; whereas,

³ Hereafter, where the U. S. Department of Agriculture has given assistance in a specific field, that cooperation is indicated by the notation "(coop. USDA)."

11.2 percent gave a varietal name. More than 2.5 times as many consumers bought red potatoes as white potatoes. Of the consumers who remembered the kind of potatoes they had as children, 70 percent usually bought the same kind.

Quality, price, variety, and source preferences

The St. Louis and Lincoln markets were used by the Nebraska station (coop. USDA) to study the quality-price relationship of potatoes at the retail level. The results showed that when comparable grades of potatoes were available in St. Louis, white potatoes were bought in about equal quantities to other varieties on sale at the same time. Location in the store was generally more important in determining the quantity bought than was the variety. In Lincoln, the Progress variety sold far in excess of any of the others, the White Cloud variety being a slow mover. Sales picked up when its price was reduced and it was specially advertised. Many customers preferred red to white potatoes, but a large number favored white potatoes if of good quality. Medium red, slightly long, and flat potatoes were preferred over darker red or round ones. Large-scale users favored both White Cloud and Progress, the former for french-frying and the latter for mashing. Not all markets have established preference for certain varieties, and customers are very responsive to good quality.

Studies by the Hawaii station (coop. USDA) showed that among 1,050 consumers, Island eggs were used preponderantly for table and cooking, whereas mainland eggs were used chiefly for cooking only. Price per dozen, size, and local source were the most important factors influencing consumer purchases. Lower price was a greater inducement to greater purchases than increased income or an increase in local supply. Half of the families would pay 10 cents more per dozen for the next larger size of eggs. More than half would pay a premium of 10 cents per dozen for Island eggs; but a 20-cent premium was the practical limit for Island eggs in homemakers' opinion. Almost half of the people interviewed favored eggs with brown shells; an equal number had no preference as to color.

The Kentucky station made arrangements with local producers growing two new varieties of potatoes, Chinmago and Ashworth, to place them on the Louisville market, a local produce exchange. Each variety was washed, graded, sized, and packaged separately. Six retail stores displayed both varieties along with the usual home-grown Irish Cobblers and shipped-in California "Long Whites." Buyers were allowed to choose from the 4 displays; the 952 buyers interviewed selected for better shape, brighter color, and fewer eyes. These characteristics meant more to consumers than the varieties available. Thus, locally grown quality potatoes can be marketed to advantage, but growers will need to take into account local yields and the cost of producing quality potatoes in relationship to other major producing areas. This may be a limiting factor to continued production of potatoes.

In research on consumer preference for apples, the Michigan station (coop. USDA) found little relationship between grade and retail prices of a given variety. Instead, size and color seemed to have a close relationship and significance. Defects, bruises, and the percentage of apples off-color were the major reasons why apples were not acceptable to consumers. This information gives Michigan growers

an opportunity to correct a market situation. In the past approximately 25 percent of all Michigan apples had contained grade defects.

About one-half of the bruises commonly found on apples sold over the counter can be eliminated by the use of the "Friday Pack" method of packaging apples, according to research conducted by the Missouri station. Under this method the apples are placed in separate layers, as are eggs in a case.

The Colorado station (coop. USDA) studied various aspects of consumer demand for western peaches in different stages of ripeness. Growers' incomes were materially increased by letting the fruit mature properly, since consumers prefer the firm ripe and larger peaches. A greater proportion of larger peaches per tree can be produced when growers pick uniformly at the firm stage. This will require several pickings, but the peaches will normally command the higher prices that consumers are willing to pay. When growers ship hard immature peaches they do not ripen satisfactorily in the retail store, with the result that they are not attractive, shrivel, slow down sales and, in many cases, are actually discarded as waste. This causes actual loss to the retailer, is a poor advertisement to the State which produced the peaches, and results in loss to the peach industry in that State as a whole.

The Texas station found that riper peaches are entirely satisfactory to shipper, store operator, and consumer. The volume of fruit per acre is increased considerably by the swell that occurs in the few additional days of ripening; the movement of fruit through the store proceeds much more rapidly and fewer peaches are spoiled in the store; and the quality of fruit delivered to the consumer is far superior. From the standpoint of distribution, bushel baskets and half-bushel baskets in common use were found to be poorly adapted for transporting firm ripe peaches. Spartan boxes, which are rectangular and give better support in the load, were superior to the baskets. The cell-type boxes with individual compartments for the fruit were still more satisfactory when provided with adequate ventilation.

The Florida and Texas stations are cooperating in a regional study on the consumer pattern for buying citrus fruits. Information on consumer preference and buying behavior is being obtained from retailers and consumers in selected markets. Results thus far obtained indicate that consumers are more sensitive to changes in quality of citrus products than to changes in prices. They have shown a wide preference for fresh fruit over the processed juices. This preference did not vary greatly among low-, medium-, and high-income areas. Frozen orange concentrate was preferred over canned citrus juice by those who had used both products. Consumer income seemed to affect sales; stores located in high-income areas sold a much greater volume of frozen orange concentrate than did stores located in low-income areas. The reverse sales relationship existed with respect to orange-ade.

In the Houston, Texas, area consumers preferred the pink grapefruit over the white or red, white grapefruit juice over pink, unsweetened juice over sweetened, large-sized cans of juice over small, bulk fresh citrus over packaged, and pricing by count over pricing by the pound.

In a study at the Michigan station, 20 percent of the purchasers surveyed had complaints about the eggs they bought. Most frequent were impressions that "yolks break too easily." These were followed in order by "watery whites," "spots on yolk," and "yolk too dark." Less frequent complaints were made about flavor, odor, dirty shells, and shells breaking too easily. In order to correct the various objections, the station prepared the following suggestions to egg handlers and producers: (1) A rapid turnover in stocks of eggs held; (2) greater attention to grading brown-shelled eggs because of the apparent tendency for more off-grade qualities to show up in brown-shelled eggs of so-called high quality than in white-shelled eggs; and (3) more attention by poultry breeders to development of birds which tend to lay more eggs of desirable qualities.

In another study on consumer demand for poultry and eggs, Maine station representatives had personal interviews with 600 consumers in the cities of Portland and South Portland. The survey indicated the kind of poultry purchased by housewives on those markets, how the birds were dressed when purchased, the prices paid, and the days of the week when purchases were made. The interviewers also obtained from over 100 retailers in the Portland market information on quality of poultry and other types of competing meats purchased for selected weeks. This survey showed that there is a definite need for better grading of poultry meat in order to meet consumer demand.

Packaging preferences

That housewives prefer to buy eggs that come in the long carton rather than those sold in the square carton is reported by the West Virginia station (coop. USDA). The long carton actually outsold the square carton in retail stores by a ratio of five to one. The pulp-type carton, a separate cup molded for each egg, was preferred in West Virginia over the less rigid type in which an inserted filler separates the eggs. These definite consumer preferences regarding the purchase of eggs in cartons as reflected in the trade should encourage the retail stores to merchandise their eggs in long cartons rather than in paper bags as has been the custom in West Virginia.

According to the Ohio station 77.7 percent of the 1,150 individually owned stores in the large consuming centers of the State and 100 percent of the 379 chain stores operating in Cleveland, sold Grade A large white eggs. Brown eggs were sold in 14.9 percent of the individually owned stores and 100 percent of the chain stores, whereas only 1.7 percent of the individual stores and none of the chain stores sold ungraded eggs. Of the independent stores, 42.7 percent sold less than 30 dozen of eggs per week, 40 percent sold from 31 to 90 dozen per week, and less than 4 percent of the stores sold over 240 dozen per week. Of the consumers on the Columbus market 40 percent preferred to buy their eggs from producers and to buy eggs graded for quality. Analysis of grading of eggs by individual candlers showed wide variation that could mean as much as 5 cents a dozen difference in price to producers. Cleveland retailers understand the necessity of holding Grade A eggs under refrigeration in order to maintain quality. The Ohio survey also pointed out that Columbus retailers would benefit if they overcame the reputation for handling low-quality eggs.

Cooperative Marketing and Purchasing

Time, effort, and funds expended by State experiment stations in studying marketing and purchasing operations of farmers' cooperatives have contributed much to the growth of these organizations in the past. Although other pressing problems in the field of marketing have tended to shift the emphasis to other types of research in recent years, cooperative marketing research continues important. In the past year 11 States conducted research along these lines.

Volume of business and earnings

In an analysis of business done by farmers' cooperative grain elevators, the Illinois station showed that earnings tended to increase more than proportionally as business volume increased and to decline more than proportionally as business volume decreased. Elevators with a business volume of \$800,000 showed average net earnings of \$20,000, whereas those with a volume of only \$400,000 had net earnings averaging only \$7,750. Those with a volume of \$1,600,000 had earnings approximating \$43,000. The rate earned on capital was much higher for cooperatives handling 750,000 bushels and over of grain than for those handling less than 250,000 bushels. No significant difference existed between the average earnings of cooperatives handling 250,000 to 499,999 bushels and the average of those handling 500,000 to 749,999 bushels. Total net earnings averaged greatest for those handling large quantities of both grain and merchandise, but the rate earned on capital invested was somewhat higher for organizations handling large quantities of grain and relatively little merchandise than for those handling the most merchandise and the least grain.

Differences in the volume of grain handled, dollars of merchandise sold, and dollars of service income accounted for about 85 percent of the difference in net operating expenses among organizations. An increase of 1,000 bushels in grain handled increased operating expenses about \$23, and an increase of \$1 in merchandise sales increased expenses by 10 cents, whereas an increase in service income was accompanied by 85 cents in expenses for each dollar received for services rendered.

Farmer members of Minnesota Cooperative Associations owned about 62 percent of the associations' financial resources, according to a survey made by the State experiment station. The ratio of current assets to current liabilities of these associations was two to one, indicating a reasonably good working capital position. In the fiscal year 1949-50, 1,341 associations had a volume of business totaling about \$1,270,000,000.

Grain storage operations

On the average, Oklahoma farmers cannot afford to use farm storage for cash grain when elevator storage is available through a nearby shipping point. This situation was brought out in a State experiment station study of grain storage operations which took into account cost and upkeep of storage requirements, variations in annual production, percentage of production sold and stored at harvest, existing facilities and equipment available, Government price support, and other important factors.

Other State experiment stations engaged in research on cooperative associations are Florida and Kansas, which are studying operating efficiency; Kentucky and Tennessee, making similar studies with respect to dark tobacco growers' associations; Tennessee, engaged in operating efficiency studies of 55 farmers' purchasing cooperatives in the State; Oregon, concerned with management and membership relations in its agricultural marketing and purchasing associations; and Washington, which is seeking ways for lowering costs of operating farm and country grain elevators in the State. Wyoming is making an economic analysis of agricultural cooperatives operating in that State, and Texas is studying the types of operations and services rendered by cooperatives to members.

Market Demand and Supply of Agricultural Products

State experiment stations are continuously being asked for new information that can be helpful to farmers in arriving at sound decisions with respect to current and prospective market demand and supply. For this reason, research along this line is continuously in progress at experiment stations in various sections of the country.

Hog and livestock prices in different markets

The Iowa station has pointed out to farmers that in order to realize most from the sale of hogs they must watch prices at each available market as well as prevailing sale prices for each weight at respective markets. For example, in September 1949 the Sioux City market on 200- to 220-pound barrows and gilts was about 10 cents under Chicago, although interior Iowa markets then averaged 80 cents under Chicago. By December 1949 the Sioux City market was 65 cents below Chicago and the interior Iowa markets were then \$1 below Chicago. Furthermore, in a recent analysis of seasonal trends for a 10-year period the Iowa station found that prices of grain-fed steers follow a fairly consistent pattern. For choice and prime steers, the low point was \$9.37 in June, with the high point in September of \$11.18. The spread in price between the choice and prime grades and the common grade was narrowest in May and June, being \$3.17 and \$3.14, respectively. In contrast, the widest spread came in October when the movement of cattle from the range is usually at its height. A 10-year average for this period shows that common cattle were \$4.88 below the choice and prime price of \$11.05.

Seasonal prices for California fruits

Studies by the California station of factors influencing the seasonal average price of canned Bartlett pears, clingstone peaches, apricots, and asparagus, and of fresh plums have provided basic information widely used by growers, processors, distributors, industry groups, research and educational institutions, and government agencies engaged in planning adjustments in production, marketing, and other economic functions.

Market relationships between types of tobacco

In an over-all study of demand interrelationships between burley tobacco and other selected types of tobacco, the Kentucky station applied rough tests by means of price-quantity ratios and coefficients of variation of price and quantity. Distinct differences were noted in

the results of these tests when the figure for quantity of tobacco is taken at the level of disappearance rather than of production, or a combination of production and stocks.

Larger dairy farms increase Vermont milk yields

Studies by the Vermont station (coop. USDA) on the effects of various production adjustments on the supply of dairy products have shown that important adjustments have taken place on dairy farms in the Cabot and Marshfield area during the past quarter of a century. The farms were larger in 1950 than in 1925 and there were fewer of them, and there has been a 14-percent increase in the total number of dairy cows kept. Milk production per cow increased nearly 50 percent, making a 67-percent increase in total milk production. Grain feeding increased materially. Many more farmers are using tractors. Investment per farm increased $2\frac{1}{4}$ times during the 25-year period. Total receipts in 1950 were about four times what they were 25 years ago, but total expenses had gone up nearly five times.

Sanitary regulations and milk supplies

The Ohio station studied the effect of variation in sanitary inspection, use classifications, buying plans, and prices on milk supply in Ohio markets. Detailed studies have been made of intermarket movements of milk in several of the larger city markets including Cleveland, Akron, Canton, Columbus, Portsmouth, Toledo, Lorain, and Gallipolis. Sources of additional supplies brought into these markets as emergency milk also have been checked, as well as the effect of shortages in supply upon prices paid by producers. The information coming out of this study is being used effectively in testimony before Federal milk hearings, in conferences with managers of cooperative associations and market milk administrators, and in advising the directors of organizations who are interested in expanding plant facilities.

Milk consumption trends in New York market

The New York (Cornell) station is seeking to determine the factors influencing consumption and demand for milk products in the State. Major trends and significant consumption changes are being traced and the differences in consumption rates among different population groups are being measured. The long-time trend of milk consumption per capita in the New York-New Jersey Metropolitan area appears to be downward. The highest level of consumption per capita was reached in 1944 at 0.91 pint a day. Since then the rate has declined steadily, reaching 0.76 pint a day in 1950. The level of milk consumption per capita in the area is of vital concern to the nutritional welfare of the urban population as well as to dairy farmers whose market and income depend upon it.

Deciduous fruit prices studied

Statistical studies by the Washington station (coop. USDA) of the prices received for each of the six principal deciduous tree fruits grown in the State showed that the net effect of competitive fruit production on specific fruit prices was negligible. However, there was considerable interrelationship between total competitive fruit production and farmers' income from production of all fruits, and individual fruit production.

Processing and marketing corn meal

Research by the Georgia station on the marketing and processing of corn meal, which included a survey of 252 representative corn meal millers in the State and 8 additional large milling firms, revealed specific reasons why millers objected to certain qualities in some hybrid strains of corn. It pointed to a need for improvement in the corn breeding programs in the State for the purpose of developing more desirable hybrids for use in milling corn.

Demand for cotton furnishings

In an effort to expand the use of cotton in furnishing homes, the Mississippi station (coop. USDA) sought to establish the factors that affect the demand for this purpose. The data, obtained in 1949, showed that all-cotton was the cheapest material for the majority of household furnishings where both cotton and competing materials were sold in volume. Part-cotton competed in total sales with all-cotton in numerous furnishings. The chief competing materials other than part-cotton were wool for blankets, paper and plastic for draperies, and feathers for pillows. The place of purchase was found to have only a slight effect upon the materials purchased.

Efficiency in Marketing

Efficiency in the movement of farm products from the point of production to the point of consumption has been the primary objective of much of the marketing research conducted by the State experiment stations.

Uniform accounting terms for cheese factories

Wisconsin station studies, aimed at helping operators of American cheese factories to find a basis for more accurately analyzing costs, margins, and plant efficiencies have resulted in the development of a manual of uniform accounting terminology, classifications, and procedures specifically adapted to the business of operating cheese plants.

Volume and cost in operating milk plants

A western regional study in which the experiment stations cooperated with the Department provided owners and managers of dairy plants with information on how costs change with changes in volume of production. The study determined the basic physical and economic relationship for the operation of the plants taking part in the study. Comparisons of physical in-puts of labor and capital were made in such a way that the analysis can be used under flexible conditions. For example, man-hours rather than wages are used in comparing the operations of the dairy plants. Uniform rates and costs can then be applied to the physical units and different plants in different areas in order that direct comparisons can be made of their operations. From a long-run point of view, individual plants can be adjusted for developments in technology and restudied on the basis of the changes made.

Efficient handling and packing on farms

The New York (Cornell) station (coop. USDA) is engaged in a fundamental project that is setting new standards of efficiency in specific farm marketing operations, such as preparing commodities

for market. In the case of egg packing, the average time for workers to perform basic motions, such as reach and other handling, was carefully measured and standards set to determine which method is most efficient. The various operations were broken down into small parts and compared as to time requirements and standards established involving different types of workers. The study indicates worker output resulting from the method followed, and the sequence of motions, effort, and skill. Motion pictures were made of the entire operation by different workers. The film later analyzed picture by picture the motions each worker used. Similar studies are being made for packing apples and other commodities. Experts in the field of industrial engineering feel that this study contributes distinctly new knowledge to their field. Agricultural and marketing research generally will benefit by employing in future research projects some of the basic facts established in the Cornell case studies on motion economy.

Northeast regional milk marketing study

In the Northeast, 11 experiment stations (coop. USDA) undertook a regional cooperative milk marketing study. Each station conducted those phases of the study which it was best equipped to handle. The Vermont station found that the overlapping milk collection systems in that State are very wasteful of labor and equipment, as is concentration of delivery during the critical last half hour of the milk-receiving period. A system of scheduled deliveries would save thousands of dollars, relieve existing receiving rooms of their peak loads, and reduce by 50 percent the total man-hours now charged to receiving costs but actually wasted while waiting for milk to arrive.

Often equipment in existing plants was found to be inept in relation to volume of milk handled. An additional or replacement unit would frequently increase over-all efficiency from 5 to 40 percent. Extension of a conveyor line grading to permit small haulers to unload faster and easier, adjustment of slope of the conveyor at dumping arch, and a better understanding of truck body mechanics were indicated as a few of the many opportunities for improvement. A projected milk-receiving station incorporates many of these recommendations in its design and serves as a modern pattern against which existing or contemplated plants may be measured.

Egg and poultry marketing studies

Poultry production and processing have become highly competitive enterprises. The Washington station, as its part in a western regional poultry marketing study, improved a marketing system for fryers that called for a high degree of integration extending from the producer to the retail outlet. Several plants in Washington were studied to determine scale relationships and to serve as an aid in setting up plants designed to operate at desirable economic levels. A recommended average marketing weight of 2.9 pounds for fryers proved to be desirable 95 to 99 percent of the time. This research provides a basis for securing greater efficiencies in poultry meat production and processing, which farmers and processors are adopting as recommendations are developed.

Hatcheries have consistently paid producers high prices for eggs, yet this type of outlet has been used by relatively few producers. Research at the Georgia and Mississippi stations (coop. USDA)

carried on as part of the southern regional study on poultry and egg marketing, indicates a need for further examination of the problems connected with hatchery egg production and marketing as well as local assembling problems, seasonality of production, and the development of a pricing system which will enable the farmer to know the kind and quality of eggs demanded by hatcheries.

The Mississippi station reports that the hatchery capacity has increased rather rapidly in that State. During the past year over 19 million chicks were hatched. Over half of these came from outside the State. The premium paid for hatchery eggs was about 27 cents per dozen over the average price received for eggs by all producers in Mississippi. As the figures indicate, it is profitable in many instances for egg producers to shift from the production of hatchery eggs at least during certain seasons of the year.

The South Carolina station found, in its contribution to the regional study, that many farmers pay little or no attention to the maintenance of egg quality prior to marketing. This was also true for the first buyers of eggs from farmers. The problem of maintaining quality as well as many of the other major egg-marketing problems in South Carolina seem to be directly related to seasonality of egg production.

The Tennessee station urges, as a result of its part in the regional project, that major emphasis be placed on increasing the size of commercial flocks. Publication of the results has enabled farmers in Tennessee to cut down unit operating costs by increasing flock sizes, concentrating on egg production, and eliminating waste.

The Virginia station found that the size of flocks kept in the State was rather small. It also learned that in the past recommended practices have been followed by only a small proportion of Virginia poultry producers. Country stores, consumers, local produce dealers, and hucksters are the main outlets for eggs. Only a small quantity of Virginia eggs are produced during the high-priced months. A large surplus of eggs is produced during the spring and summer months when prices are lowest.

In connection with regional egg-marketing research in the Northeast, in which 10 experiment stations took part (coop. USDA), a study was made of the schedules of egg-marketing practices of 3,276 retail stores. Samples of egg lots were studied for quality and egg size. The information obtained in this investigation will serve as an important guide for producers and retailers of eggs. Under this project also a study was made of the factors affecting sales. Results indicate that it is desirable to cater to customers' likes and dislikes by offering different selections of eggs. The results will serve as a basis for emphasizing the importance of the retail function of egg marketing in the Northeast during summer months when maintaining egg quality becomes a special problem. It will also give many retailers a yardstick for measuring their efficiency in egg marketing.

Wide publicity has already been given results obtained in the north central regional egg-marketing project. One phase of the project dealt with the loss of egg quality in marketing. The quality of eggs marketed by many farmers in the region appeared to be inferior to the quality of eggs marketed by other producers. The main reasons for the low quality of eggs marketed were given as inadequate storage on farms and infrequent marketing; the deterioration of eggs in

buying stations brought about by inadequate refrigeration facilities; and infrequent shipments to second receivers. Such practices lowered the percentage of high-grade eggs received at assembling points. A relatively large percentage of eggs produced in some areas in the Middle West are broken and processed in drying plants. The information obtained in this study, on the factors responsible for low quality in eggs, has aided farmers and handlers to take steps that will improve and maintain a higher quality of market eggs.

In a second phase of the North Central regional project, labor efficiency and cost studies are being conducted for egg-grading stations under various seasonal and volume conditions. Preliminary figures show that it took an average of 13.2 minutes to candle a case of eggs and 11.3 minutes to pack eggs into the case at a total cost of approximately 35 cents per case. Forty percent of the working time of candlers and packers was occupied in work other than candling and packing. Furthermore the study showed, candlers spend part of their time doing jobs that could be done as readily by less skilled employees. Results obtained in this study will enable grading stations to improve efficiency and lower costs and at the same time adapt their operations to shortages of skilled labor resulting from the defense program.

Efficiencies in fruit and vegetable marketing

Vermont's apple industry is adopting new methods in packing plant operations as a result of common inefficiencies disclosed in an experiment station study of 13 apple-packing plants. Hand methods and the use of machines for sorting and sizing were compared, and measurements were made of the time required to do various jobs under different methods of operation. Lay-outs of plants and the direction of flow of apples were studied and losses through bruising were measured. Plants using machines to sort and size apples showed higher output per worker and lower cost per box of packed fruit, but none of the packing houses showed full efficiency in all jobs involved.

A study conducted by the New York (Cornell) station (coop. USDA) on the merchandising of fresh vegetables in 230 Syracuse retail stores showed that type and location of the store and size of business are the most important factors affecting sales of vegetables. The most successful merchandising of perishable vegetables was associated directly with the rate of turnover, which was affected by prices, display, watering of the vegetables to keep them fresh, and by trimming, and by the purchasing policy of individual retailers—frequency of purchase, quantity bought, and the variety of vegetables handled. In the handling of loose leafy greens, reduced sales and spoilage loss resulted from inadequate refrigeration and watering.

Cooling and bulk handling of the unhusked product is the most desirable way to preserve the quality and sweetness of sweet corn in marketing, according to the information obtained in a carefully planned marketing study conducted by the Minnesota station. The station did this research at the point of production about 25 miles from the wholesale outlet to which the corn was trucked. For comparison, three methods were followed. Under the first method, the corn was husked, hydrocooled, packaged, iced, and placed in cold storage before shipment. Under the second method, unhusked corn was kept

in refrigerated trucks until it was shipped. The third and last method studied was the conventional method of keeping unhusked, iced corn, which was used for comparison. As measured by moisture and sugar content and by taste tests, the quality of fresh sweet corn handled by the conventional method was distinctly inferior to that of the corn cooled on the farm and kept refrigerated during its movement to market. But the husking, hydrocooling, prepackaging, and icing of sweet corn was found to be approximately five times as expensive as merely icing the unhusked corn.

Tests of consumer-size-unit packages for apples in retail stores made by the Kansas station showed that 5-pound snap sack cellophane bags were extremely popular with both retail and packing shed operators. Bulk sales of apples have normally been made in units of 2 to 3 pounds. In comparison it was found that the volume of sales in 5-pound cellophane bags was practically that of bulk sales. For larger unit purchases the half-bushel sales on a volume basis outsold bushel sales by more than three to one. The station also learned that Kansas-grown sweetpotatoes can be profitably washed and waxed at harvesttime before going into storage. Kansas-grown sweetpotatoes were generally purchased on in-State and out-of-State markets because of these recommended washing, waxing, and grading practices.

Efficient farm marketing of cotton

Eleven States (coop. USDA) are taking part in a southern regional cotton-marketing study. The primary objective is to determine the efficiency in the movement of cotton through local and central marketing channels. As its contribution to this regional project, the Alabama station has completed tabulation of data obtained from 67 Alabama cotton mills during the past year. Strength and hard-bodiness of the fiber and smooth preparation were among the most important fiber properties considered by the mills in purchasing cotton. Thirty-eight percent of mill cotton requirements was purchased on actual sample, 41 percent on description of official grades, and 21 percent on "private type." Data obtained from 21 cotton buyers and 15 warehousemen in the Piedmont area of Alabama were used in studies relating to marketing channels, services performed, and charges incurred on cotton moving through various channels.

Simpler method for pricing tobacco leaf

To demonstrate the feasibility of a universal grading system for tobacco leaf, and to establish bases for such a grading system, the North Carolina station analyzed tobacco marketing data covering the marketing season 1948-49. The analyses are designed to single out relationships between the U. S. grades and grades used by buyers. Multicontingency tables showing Federal grades, company grades, and prices have been prepared and studied. These are now in the hands of statisticians who are reviewing them for pilot study in actual markets. The aim is to make the pricing of tobacco leaf simpler and more efficient.

Injury a minor consideration in mechanical apple grading

The 1950 report told of studies made by stations in the North Central States on losses sustained through bruising in the packing

of apples. In a similar study the New York (Cornell) station found that many growers resort to expensive hand methods in packing apples in order to avoid mechanical injury caused by grading equipment. The records indicated that there is some variation in bruising caused by different makes of mechanical graders, but that most of the bruises are small compared with those occurring in marketing channels. The question of injury to apples should, therefore, not enter into decisions on whether to size and grade McIntosh apples by machine or hand. Cost involved, rather than injury, should be the criterion. Many growers can lower their costs per bushel by using the mechanical grading method because it will result in the greatest physical output per hour.

Economic analysis of milk-drying plants

Average manufacturing costs per pound of dry milk produced in Minnesota spray-drying plants were 4.52 cents in 1949 compared to 4.88 cents in 1948 and about 3 cents in 1940, according to the Minnesota station. Per unit costs of operation were somewhat lower in 1949, largely because of an increased volume of output per plant, somewhat lower fuel oil prices, and a more efficient utilization of labor. The study indicated that drying plant operating costs could be reduced in a number of ways. Hauling and milk assembly costs could be lowered by transporting more milk direct from farms to central plants. Large-scale plants can be operated at lower cost than small ones. Costs can also be reduced by operating plants near full capacity and by introducing more labor-saving devices.

Whole milk volume in Minnesota

Minnesota creameries increased the volume of whole milk they handled from about 12 percent of total receipts in 1934 to about 60 percent in 1946, according to long-time records kept by the experiment station. Creameries that remained on a cream basis showed only a 5-percent increase in volume of butterfat receipts as compared with a 22-percent increase in creameries that shifted to the whole milk basis. Truck assembly of milk and cream increased considerably in the plants which shifted to whole milk. In 1934 truck routes of the plants shifting to milk averaged 115 miles per plant. By 1948 the average had risen to 201 miles, an increase of nearly 75 percent.

Whole milk operations called for heavy investments in new equipment, buildings, and central drying plants. Fixed assets of plants shifting to whole milk averaged \$72,395 per plant as compared with \$34,886 in plants remaining on a cream basis. Heavy borrowing was necessary to finance this shift. The proportion of all assets supplied by the members declined from 73 percent in 1934 to 62 percent in 1947. Total operating costs in whole milk creameries averaged 5.617 cents per pound of butterfat handled as compared with 4.979 cents a pound in cream basis plants. In 1947 the whole milk creameries were able to return an average of 89.2 cents a pound butterfat to patrons, or about 7 cents a pound more than the cream-basis plants. Larger plants were able to pay patrons more per pound of butterfat than smaller plants.

Cost of making creamery butter

The Iowa station made field surveys covering 13 selected creameries during the spring and summer of 1950. Each plant was studied intensively as to costs of building, equipment, labor utilization, and other manufacturing costs. Cost of manufacturing a pound of bulk butter in the 13 sample plants varied from 8 cents in the smallest plant producing slightly less than 200,000 pounds annually, to 2.5 cents in plants manufacturing close to 3,000,000 pounds annually. When the cost of the sample plants was considered in two categories, (1) plants operating with one churn only, and (2) plants operating with two or more churns, the most significant decrease in cost occurred in the one-churn plant as the volume increased from 200,000 pounds to about 750,000 pounds annually. This decrease amounted to 4.5 cents per pound and should be attributed to better utilization of equipment capacity.

In one-churn plants making more than 750,000 pounds of butter annually the cost tended to increase. In plants using two to three churns, the manufacturing cost decreased at a rather constant rate from 4.5 cents in the smallest plant producing slightly over half a million pounds annually to 2.5 cents in the largest plants. A well-managed, one-churn plant producing close to 750,000 pounds annually could manufacture butter at a cost of only 0.7 cent per pound higher than that of the most efficient large plant producing 3,000,000 pounds annually.

Labor management in tobacco warehouses

Research on the efficient use of labor and equipment in handling tobacco on loose-leaf warehouse floors, reported by the Kentucky station, pointed to a number of economies that could be made. In the loading out of burley tobacco after sale, trucks were found to stand at the load-out point an average of 5.25 minutes, 2 minutes of which were devoted to actual loading and 1.7 minutes to spreading and tying a tarpaulin over the tobacco. Two men usually did this work. Warehouse employees who moved tobacco to the trucks were idle about 2.5 minutes of the 5 while the truck crew prepared the truck for loading and leaving. In addition, the intervals between the arrival of trucks, varied up to 30 minutes and averaged 4 minutes; thus the warehouse load-out crew was idle about two-thirds of the time. Much of this loss probably resulted from the lack of coordination between the two crews of men, each of which was under different supervision and direction. The study points to the need of economies in the use of labor under conditions of manpower shortage. Reorganization of the method of handling load-out crews and the use of quicker ways of covering tobacco could save 25 percent in the time employed.

Factors Affecting Distribution and Consumption

Of the many factors which influence the distribution and consumption of agricultural products those which are of greatest significance at the present time are transportation costs and services, marketing control programs, inadequate information on market prices, supply and demand for various agricultural products, and the losses sustained through transportation as well as the condition of the product at the time of sale. The examples given below are representative of research

under way by the State experiment stations in an effort to supply information that can solve such problems.

Western turkeys in eastern markets

Three western experiment stations (coop. USDA) are taking part in a regional study of the cause of the gradually shrinking market on the east coast for western turkeys. The Oregon station found that western turkey growers have partially offset the disadvantage in transportation rates by producing a superior product and by achieving greater efficiency than other areas in marketing their flocks. However, turkey growers in competing areas are gradually improving their product and are becoming more efficient. Therefore, unless some development can halt or reverse this trend now under way, the time is not far distant when the western growers will be forced to make a critical appraisal of their position in the production and marketing of turkeys. The industry will have a choice of three alternatives—curtailed production, the production of smaller turkeys, or marketing the large turkeys now produced more efficiently.

Effect of freight rates on marketing farm products

The increase in freight rates on farm products to outside markets has been a major factor in restricting the movements of these products to certain areas. The influence of transportation costs on the movement and marketing of fruits and vegetables was given primary consideration in a Utah station study. The services and the lower rates provided by trucking companies have resulted in an increase in truck tonnage from this area. Data on changes made in services and costs provided by rail and motor trucks are of economic importance to both producers and shippers in planning their operations. Such information is particularly valuable at a time when large volumes of heavy defense materials compete vigorously for shipping space on rails, forcing more farm products and farm supply shipments to be sent over the trucking routes.

Salt Lake City Growers Market

In a study on the operation of the Salt Lake City Growers Market, and its relationship to the marketing of fruits and vegetables, the Utah station found that during a 4-month period fruits and vegetables valued at \$960,000 were sold over the marketing platforms. Growers in Salt Lake and David Counties sold 85 percent of the produce on the platforms. About 35 percent of the production of fresh fruits and vegetables of these two counties were sold through the Growers Market outlet. About one-third of the produce sold on the platforms was purchased by wholesalers, one-fourth by truckers, a little less than one-fifth by chain stores, and the balance by city retailers, peddlers, platform retailers, and consumers.

California grape-marketing programs

To aid industry groups, farm organizations, grower groups, and administrative committees of the State and Federal government responsible for establishing policy in marketing programs, the California station undertook a study on the economic effects of grape-marketing-control programs. The study provided an analysis of basic problems leading to control in the grape, wine, and raisin industries. It also included an appraisal of the grape-market-control

program in operation between 1929 and 1941. In addition, the development and operation of programs under California law are being studied, including the status of legislation, the types of programs, and administration.

Potato shipping containers

The Maine station (coop. USDA) secured the cooperation of the Bangor and Aroostook Railroad in a study of shipments of potatoes in various types of containers. The purpose was to learn which containers best protected potatoes from cuts and bruises. Two shipments of potatoes in several different types of containers were made. Paper containers offered little protection from bruising, but bruising damage was considerably reduced when potatoes were shipped in corrugated cardboard and wooden boxes and in wooden crates.

Merchandising flowers

The Michigan station made an analysis of wholesale flower markets and basic trends for the past 10 years in retail flower sales in Michigan; also of the effect of advertising and other merchandising practices on sales volume and the type of market served by fruit stands which sell flowers. The analysis indicated that present-day wholesale market reports are inadequate; the proportion of the consumer's dollar spent for flowers in Michigan is less than that spent for many other so-called luxury items; relative to other merchandise, flower sales have tended to decline from the high wartime level; institutional advertising does not appear to boost florists' business in the short run; and that fruit stands sell flowers mainly for home use, in small unit purchases, and do not achieve a large total volume.

Marketing Costs and Margins

Ways and means for bringing about greater efficiency in the distribution of agricultural products from the point of production through the various trade channels to the consumer are constantly sought by producers and handlers of agricultural products. Both are interested in increased efficiency and reduced costs in order to meet competition. Many requests for research along these lines are coming to experiment stations.

Poultry marketing costs

The Michigan, Minnesota, and Wisconsin stations (coop. USDA) reported that in poultry marketing about two-thirds of the consumer's dollar goes to the producer and the other one-third to the marketing system. The following recommendations to reduce marketing costs grew out of the study: (1) A concentration of egg production in the area surrounding the egg-assembling station would reduce the cost of assembling eggs from the farm; (2) more uniform egg production throughout the season would reduce the unit assembling and plant cost of the central assembler who is now faced with incomplete utilization of certain equipment and personnel during the short production season of the year; (3) reduction of the cost of the central assembler through the handling of an optimum volume of business in relation to his natural source of egg supply, his capital investment, and his market outlet, and (4) reduction of the rate of quality deterioration of eggs at the farm, in the plants, and en route to the market. De-

terioration in quality amounts to a real part of the marketing cost.

The results of the study further suggest that: (1) Competition for top-quality eggs among wholesalers, central assemblers, and other egg buyers may not be sharp enough to force the highest possible degree of operating efficiency among most egg dealers, so that the ones who handle these quality eggs most efficiently are apparently able to enjoy a considerable margin over costs; (2) egg handlers (central assemblers) who market top-quality eggs generally pay a premium for them; and (3) if lasting improvement is to be made in egg quality, a larger proportion of the premium paid for quality by consumers must be passed back to producers. This can be done by increasing the efficiency of marketing and by setting up a competitive situation so that margins over costs will be held to a minimum, consistent with sound business practices.

Packing and selling citrus fruits

Costs of packing and selling citrus fruits were obtained by the Florida station (coop. USDA) for 75 packing houses, 20 canning plants, and 8 frozen concentrate plants in Florida, and by the Texas station (coop. USDA) for 24 packing houses and 13 canning plants in that State. A wide variation in cost between firms was found. Ten percent of the firms reported the cost of packing and selling oranges in bruce boxes at less than 75 cents per box, whereas another 10 percent placed this cost at over \$1. The average cost was 87 cents per box. Cost by type of container was 87 cents for bruce boxes, \$1.02 for standard boxes, and for box equivalent in bags, 69 cents for ½-box bags, \$1.02 for 8-pound bags, and \$1.24 for 5-pound bags. As the volume increased by 100,000 boxes, the cost decreased by approximately 3 cents per box. Cost of processing citrus pulp was \$26.98 per ton, and for citrus molasses \$23.67 per ton. The research revealed that most firms could lower their cost of packing and selling citrus fruits by from 2 to 10 cents per box.

Public eating places market 15 percent of food

Since public eating places sell many services along with food, it is to be expected that their gross mark-ups will be much larger than those in retail food stores. That this is so was confirmed in a study analyzing eating places as markets for farm food products, particularly in Minneapolis and Fairmont. The Minnesota station (coop. USDA) found that Minneapolis eating places distributed about 20 percent of the value of all meat sold in the city; about 13 percent of the value of fresh fruits and vegetables; and about 16 percent of the value of all other foods. In total figures, about 17 percent of the value of all foods was sold through eating places. Eating places in Fairmont distributed about 15 percent of all food sold in the city, which is in line with estimates of the national average.

Economics of broiler production

Fifty-six percent of the broiler producers in northwestern Arkansas sold less than 5,500 birds, according to the Arkansas station (coop. USDA). Twenty percent sold 10,500 or more birds per year, and about 80 percent of the birds were weighed at the farm. About 75 percent of the broilers were sold to shippers and 22 percent to local processors. Average weight of all birds sold was 2.83 pounds, and 87 percent were sold at ages from 9½ to 12½ weeks. Farm prices f. o. b.

conformed closely to wholesale prices for young chickens in Chicago, St. Louis, Fort Worth, and New Orleans. Processors paid about one-third cent more per pound than shippers. Breed, size of brood, and average selling weight did not significantly affect price received per pound. Two-thirds of the producers were satisfied with the present method of selling broilers.

During the summer of 1950, 96 broiler farms and 9 of the major dressing plants producing 214 lots of broilers in Maine were surveyed by the State station to determine costs, returns, and management practices of growers, also dressing plant costs. The study showed that nearly 90 percent of the broiler farms in Maine are assisted by the dressing plants under various types of financial agreements.

Margins in Indianapolis apple distribution

As a contribution to a regional study, the Indiana station (coop. USDA) gave consideration to margins taken in the distribution of apples. Beginning with the fall of 1950, detailed records on apple margins were kept in cooperation with 15 Indianapolis retail stores. A record of margins was also made to determine the seasonal movement of margins in the Indianapolis market. A report was made available to the wholesale trade of the Indianapolis market as well as to cooperating retailers.

Cost of producing milk in Tennessee

The Tennessee station (coop. USDA) reports that cost of production seems to be a limiting factor in expanding the market for dairy products in the State. The station's study of this factor shows that the average gross cost of keeping a cow for the year ended July 31, 1949, was \$306.48, of which 59.5 percent was for feed, 13.9 percent for labor, 8.7 percent for cow cost, 8.3 percent for buildings and equipment, 4.2 percent for hauling milk, and 5.4 percent for miscellaneous cost. The cost per 100 pounds of milk ranged from \$3.29 in May to \$7.83 in December. The average feed cost was \$182.30 per cow, or \$3.10 per 100 pounds of milk. Of the total feed cost 46.2 percent was for concentrates, 44 percent for roughages, and 9.8 percent for pasture. Net returns averaged 62 cents per 100 pounds of 4-percent-milk produced, or \$33.63 per cow.

The range in net returns was from a loss of \$1.64 per 100 pounds of milk produced in December to a profit of \$2.13 in August; or from a loss of \$6.83 per cow in December to a profit of \$12.36 in May. The milk distributors' spread in Memphis in 1948 was one of the lowest of the large cities in the United States. A quart of milk was delivered to the Memphis consumers' doorstep for an average of 18.8 cents, of which the producer received 12.8 cents. Salaries and wages comprised more than half the cost of distribution.

Basis for establishing price ceiling

Studies conducted by the Texas station (coop. USDA) furnished data that enabled the Office of Price Stabilization to issue a supplementary regulation affecting citrus juice prices. It provided for an equitable upward adjustment in Texas citrus juice ceiling prices by exactly the same amounts that the Texas cost studies had established. This increase provided growers and canners with more than a half million dollars which aided greatly in relieving in part the financial

squeeze confronting the Texas citrus industry as a result of price regulations.

Reducing curding time for cheese

The Wisconsin station reported research on new methods of processing cheese and the development of new equipment. The station studied the characteristics and properties of curd made by a new method. Aside from the fact that it produces a desirable cheese, the new method could be used to handle the curding process almost completely by mechanization and in approximately 3 or 4 hours as compared to the 5.5 hours necessary under previous methods.

The station also continued research intended to develop more complete mechanization of the process of making stirred curd types of cheese. Different mechanical devices have been used to increase efficiency. The study showed that there is a need for a safety type of ladder to be used by plant workers who must get in a high vat to clean it. A ladder was developed which slips over the top of the vat and is held firmly in position by the unusual curvature of its legs. Experiments were carried out in the temperature control of cheese during pressing by means of a hood. In the past, cheesemakers have used steam or hot water or both to warm the curd before pressing, but heretofore no scientific control of pressing temperatures was available. The Wisconsin method is still in its experimental stages.

Cost of milk distribution in Portland, Oreg.

Detailed cost data from 20 milk distributors in the Portland milk market were taken by the Oregon station from actual records of firms that handled 95 percent of the fluid milk volume in 1949. One of the most important phases of the project was the determination of appropriate allocation procedures so that unit costs of distribution by functions might be computed. If establishment of unit costs is to have practical value, allocation procedures must be acceptable from the accounting point of view. Records on milk sales and costs were obtained from about 35 retail food outlets in the Portland market. These 35 outlets represented a fairly satisfactory cross section of the retail food business conducted by chain stores, and large independent, medium-size independent, and small independent distributors. A preliminary analysis of unit cost figures so far obtained in this continuing study indicate that labor costs represent 50 percent or more of the total costs of distribution.

Marketing and Merchandising Methods

Marketing and merchandising methods change from time to time, and often are in response to marketing and distribution research. Some changes are rather simple in nature and easily made, whereas others are complex and can be made safely only after considerable time and effort have been put into studying the consequences. That is why the experiment stations, which have made such valuable contributions in economic research, including the field of agricultural marketing, are conservative in recommending changes in marketing methods. The immediate and long-time effect is usually weighed in additional research before new practices are recommended that may bring too rapid, wide-scale innovations.

Meat distribution problems

The Kansas station points out that one of the biggest problems of meat distribution is caused by the large number of small-sized stores. In a survey conducted by the station, more than 40 percent of the stores were found to have gross meat sales of less than \$1,000 per month. Ninety-nine percent of all meat was delivered to the Topeka stores in wholesalers' trucks. The average store was purchasing meat from 6 different wholesalers, and some stores from as many as 12. In large stores nearly one-half of the total retailing costs were for labor. Some changes in methods need to be considered in both the purchasing and distribution procedures in order to get greater efficiency and savings. If meat can be distributed more cheaply, consumers will be able to buy more and better cuts and thus provide a broader market for livestock.

Moisture protection in egg storage

The Kansas station (coop. USDA) showed through research that eggs should be handled and stored as free from moisture as possible. Dirty winter eggs stored at 65° F. showed microbial deterioration ranging from 2 to 27 percent over a period of 8 months. Groups of dirty, late-summer eggs similarly treated and stored showed microbial deterioration from 15 to 37 percent. Neutralization with tartaric acid did not affect antibacterial action as thoroughly as did yolk neutralization.

Food lockers and freezer plants

The importance of frozen food locker plants and freezers in the marketing of livestock and meat, livestock slaughter, and meat distribution were studied in a North Central regional project (coop. USDA). The study was based on conditions in 1947, and data were obtained from 576 frozen food locker plants, 3,947 patrons who rented lockers, and 2,156 users of home freezers. Six-hundred twenty-two million pounds of red meat were processed during the year by all locker plants in the 9 States included in this study. Processing of poultry was less extensive than that of red meats. Approximately 86 percent of the meat stored was produced from local slaughter, 12 percent consisted of carcasses and parts of carcasses purchased as wholesale cuts of meat, and 2 percent was cut and wrapped by the patrons before delivery to the plant. Three-fifths of the plants sold wholesale, and 90 percent of the meat thus sold went to locker renters.

Of the 2,156 home freezer owners who furnished information for the study, 69 percent resided on farms, 31 percent in towns. Farm owners of home freezers reported that they stored 804 pounds and city owners 555 pounds of meat, poultry, fish, and game, contrasted with 304 pounds of these products stored per locker in all plants taken into consideration. Reports from farmers showed that they stored about 60 percent more meat but 10 percent less poultry in their home freezers than city owners. Locker renters reported that family meat consumption, especially of beef, increased after they rented the lockers.

Milk marketing and distribution in Arkansas

A State station survey of milk marketing and merchandising revealed that about 15,000 farmers supplied the milk plants in Arkansas with about 466 million pounds of milk in 1949. About 431 million pounds were produced by 14,000 farmers in Arkansas, and the balance

of 35 million pounds was supplied by 1,000 farmers just over the border in adjoining States. About 22 million pounds were used by producer distributors; 169 million pounds were sold to bottle milk plants; and 275 million pounds to manufacturing plants.

In addition to the amount of milk produced by farmers living in the State and within the normal supply area of plants near the border of the State, bottle milk plants imported about 4 million pounds of fresh fluid milk; 2 million pounds of condensed skim milk; and 300,000 pounds of nonfat dry-milk solids. A few plants imported milk each month in the year, but many imported milk only during the short winter months, mainly from Missouri and Illinois. Producers for bottle milk plants had a seasonal increase of 37 percent from the low-production months to the high months of production, whereas producers for manufacturing plants had an increase of 163 percent.

Marketing western livestock

Considerable change has taken place in recent years in the buying and selling of western livestock. The 11 western experiment stations are cooperating in a regional study to establish more reliable information on how and where livestock is going to market. The California station (coop. USDA) collected data on the operations of dealers at livestock auctions. Records obtained from 349 dealers (154 in California) in 6 Western States indicate that an equivalent of 684,297 head of cattle was handled in 1949. Farmers and dealers were the major buyers and sellers at livestock auctions. Only 28 of the 349 dealers handled more than 5,000 head in a year. Farmers and livestock auctions furnished 54 and 30 percent, respectively, of all livestock handled by dealers, and the remaining 16 percent was obtained in approximately equal numbers from other dealers and from public markets.

Outlets for the dealer were the wholesale butcher or packer, who took about 28 percent of the animals, and farmers, who purchased approximately 28 percent; followed by auctions, 22 percent; public markets, 11 percent; other dealers, 8 percent; and other outlets, 4 percent. The Colorado station found that stockmen follow a wide variety of methods in selling feeder cattle, and that there is much duplication of sale and considerable cross haul of cattle between the producer and the packer. A pronounced increase in year-long fattening of cattle in Colorado within the past few years partly reflects the great expansion in demand for meat in the West. More Colorado cattle move west than was the case in the years before World War II, with an accompanying reduced eastward movement of feeder cattle.

Trucking costs in poultry and egg procurement and delivery

The daily fixed cost of operating trucks for gathering poultry and eggs averaged \$1.74 for 43 procurement plants studied by the Indiana station. The study divided cost factors into three main classifications: Fixed costs, variable costs, and labor costs. The fixed cost varied with the size and age of truck. Twenty routes operated by 4 plants averaged 97 miles in length and ranged from 47 to 176 miles. The number of producers per route averaged 32 and ranged from 17 to 47. At least four stops during which no eggs were collected were made on each route. A study to establish the costs and other economic factors involved in the use of trucks in retail egg delivery is under way at the Storrs station (Connecticut).

Price advantages of graded eggs

The conventional marketing of eggs by Kentucky farmers has been on the current-receipt basis. This method has not been satisfactory, however, to buyers who want closely graded, high-quality eggs. For such eggs the trade has looked to out-of-State sources. In a study carried on by the Kentucky station it was shown that Kentucky farmers can obtain 3.5 cents per dozen more for closely graded, high-quality eggs than they can for current-receipt eggs. In analyzing a graded buying program, the station found that 78 percent of all eggs delivered were rated as A's; 15 percent, B's; and 7 percent, undergrade. In contrast only 48 percent of the "farm run" sales graded as A's; 19 percent, B's; and 41 percent, undergrade.

Cotton marketing and quality studies

Eleven experiment stations in the southern region are cooperating in a cotton-marketing study (coop. USDA), the results from which are expected to serve as a guide to cotton farmers and the cotton trade in their cooperative planning toward better marketing efficiency. In this regional study, the Louisiana station has obtained comparative factual information on marketing practices in organized and unorganized parishes raising one variety of cotton. Other research at the Louisiana station indicates that there is a direct relationship between the size of ginning plant, the volume of cotton ginned, and the ginning cost per bale. There is a need for greater cotton-drying capacity in southern Louisiana.

The Mississippi station showed that demands for cotton are influenced largely by end products of the mills. Producers of highest quality textiles used relatively more cotton from the Delta, whereas manufacturers of coarse yarns used relatively more from the Southeast; those producing very coarse and low-quality textiles procured more cotton from the Southwest and Far West. The greater part of the marketing charges represent costs over which cotton buyers had no control. In the Delta and central areas, transportation accounts for approximately one-third to one-half of the total marketing charges, plus an additional one-fourth for other services which cotton buyers obtain from other agencies. Variations in environmental conditions and cultural and ginning practices, even within one-variety communities, give rise to marked variations in grade and staple. Information with respect to variety and areas of growth was shown to be used only to a very limited extent by the trade in assembling and marketing cotton. Less than 2 percent of the certified cotton that had been traced through trade channels reached the mills in all certified lots.

The Missouri station found that farmers in the State sell all of their cotton to the ginner. The major part of the cotton is then sold by the gin operator through a broker. In only a few instances are any charges assessed directly against the farmer. Rather, the cotton moves through the market and each successive buyer calculates his price to adjust for these accumulated charges, such as transportation, warehousing, and compressing.

In view of the renewed war-stimulated interest in American-Egyptian cotton a mathematical study of the price and production relationships between American upland cotton and American-Egyptian cotton has been undertaken by the Arizona station. It is planned to incor-

porate the significant findings of this mathematical study of relationships in a publication on American-Egyptian cotton.

Purchasing feeder livestock in Missouri

The majority of hogs, cattle, and sheep sold at auctions as feeders in Missouri are purchased by farmers for further fattening, the State station reports. This does not represent a direct sale between the livestock raiser and feeder in most instances, since the most important channel for selling feeder stock was found to be the country livestock dealer. Since the selling price of feeders at these country auctions depends largely on the price paid for livestock at the large public stockyard markets, the price paid the farmer for feeder animals must allow for trucking charges, auction charges, and the margin of the country buyer. The popularity of the auction sale, therefore, appears to be based more on custom than on any economic saving to the farmer.

Marketing livestock by carcass weight and grade

In a regional project being conducted in the North Central States (coop. USDA) on the marketing of livestock by carcass weight and grade, nine experiment stations are participating and four others are cooperating. The species of livestock under study include cattle, veal calves, sheep, lambs, and hogs. The 1949 report gave some of the progress made in this project in the study on marketing hog carcasses, as summarized from the Minnesota station's contribution to the project.

The Missouri station (coop. USDA) collected data on 592 hog carcasses at a commercial packing plant. These included measurements of the carcass and weights of wholesale components of each carcass. The physical carcass measurements were related to the value of four lean cuts. Simple correlations of length of leg, length of body, and backfat thickness were computed. The highest average correlation was found between backfat thickness and value of lean cuts. Selected partial and multiple correlation did not show an improvement over relationship of single backfat measurement to carcass value. Further analysis of basic data included the application of 1949 Chicago average wholesale price to components of the carcass. Standard deviations by weight and grade were computed against tentative carcass grades. The findings of the study will be helpful in promoting the use of better live grade standards based on carcass values. The benefits of this research can be passed on to livestock producers by getting them to adopt carcass grade standards more generally.

The Missouri station (coop. USDA) also specified the physical measurements of 529 beef carcasses that had been collected. The measurements used were those believed to be significant in obtaining possible relationships between the physical measurements and Federal carcass grades obtained on each carcass. Multiple correlation computation was made of the 7 measurements which had previously shown promise in simple correlation. These measurements were correlated with Federal grade. None of the measurements singly or in combination showed promise in predicting grade of carcass. The major difficulty, with regard to beef carcasses, is to find an objective way of comparing physical measurements with quality of the carcass.

How Pennsylvanians buy fruits and vegetables

The Pennsylvania station conducted a survey on marketing methods of fruit and vegetable growers, covering most of the important fruit

and vegetable areas in the State. The outlets used, the functions performed by growers, the type of containers used, and other marketing practices were studied. The research emphasizes a wide variety of marketing practices used by Pennsylvania growers as well as a large number of outlets open to them. The survey showed that about half of the consumers interviewed purchased all their foods at one store, about one-fourth in two stores, and the remainder in three stores. In practically all cases consumers selected a store as a place to purchase groups of food products rather than any individual items. Price, quality, and convenience were indicated as the important factors involved in the selection of food stores for retail purchases. When asked about their purchasing habits for specific commodities—apples and potatoes—the proportion of the consumers who replied that they would go without apples was much higher than the proportion who said they would go without potatoes, if the quality offered at the store where they made most of their purchases was not satisfactory.

Purchase of frozen foods

In a study of methods of merchandizing frozen foods, the Ohio station learned through interviews with families and proprietors or representatives of stores, that consumption of commercially frozen foods could be increased through better merchandising, better packaging, and lower prices. Many families do not use frozen foods; and most families who do buy, purchase only in moderate amounts. Still others, largely in rural communities where lockers or home units are used in addition to purchasing frozen foods at retail, are fairly heavy users. In the latter group, some use more than 100 pounds of frozen foods per family member per year. Locker use has reached its practical limits, whereas home units will expand considerably if the intentions of the families interviewed are carried out. Most of the future expansion in use of frozen foods will probably come through commercial channels.

Merchandising Ohio apples

Surveys on retail apple marketing were conducted by the Ohio station in 118 stores in Cleveland and 86 stores in the Canton-Youngstown area, during the fall and early winter of 1950. At the same time surveys of wholesale distribution were made in Cleveland, Cincinnati, Columbus, Youngstown, and Pittsburgh. A consumer survey was conducted during December 1950 and January 1951. This study has revealed the competitive nature of the markets for Ohio apples. For example, 11 States and British Columbia were offering apples on the Cincinnati and Cleveland markets.

The retail and wholesale surveys showed that the most important problem in handling Ohio fruit was that packs did not conform to grade. Fewer than 23 percent of the customers interviewed in the retail study were familiar with the important varieties of Ohio apples, except Golden Delicious. Growers can plan or gear their production and marketing to better meet the demands of the trade by recognizing the competitive position of the market for Ohio fruit, the problems associated with handling fruit, the consumers' knowledge of Ohio fruit, and the factors that guide customers in purchasing it. The trade can gain only by providing the customer with a more acceptable product.

Improved merchandising of apples

The New York (Cornell) station recorded the apple purchases and related shopping habits of some 80,000 customers in 4 New York cities in order to determine the influence of quality apples and methods of merchandising on the volume of fruit sales in retail stores. Pounds of apples sold per 100 customers varied from 11 to 33, depending on sales methods employed and the quality of apples. When apples were offered in 4-pound transparent bags and in bulk, sales per 100 customers were 20 pounds; in 4-pound bags alone, 18 pounds; in 2-pound bags and bulk, 13 pounds; in 6-pound bags and bulk, 28 pounds; and sales of highly colored apples in 4-pound bags with bulk, 33 pounds. Window displays of apples increased sales 25 percent. Preliminary results of this research were quickly accepted by trade journals and grower organizations. Stores also put the findings to their first practical test in moving last year's large McIntosh crop.

New Mexico vegetables for long-distance shipment

The New Mexico station is attempting to determine the different methods and channels by which carlot and truck lot sales of vegetables are made and the suitability of these different methods. Fifty producers and shippers were interviewed in Roosevelt, Lea, Eddy, and Dona Ana Counties, and costs incurred by the farmer were obtained for grading, packing, and selling. There are indications that New Mexico growers can compete favorably with other areas in production and that the major handicap to the vegetable industry in that State is in the field of marketing. Stabilized production of specific vegetables from year to year would allow and encourage the establishment of adequate market facilities. To gain greater acceptance on the major vegetable markets, New Mexico growers could concentrate on producing vegetables that will withstand long-distance shipping.

Grading chickens on Salt Lake City market

A serious need for revising grading and buying methods of poultry on the Salt Lake City market is indicated in a study conducted by the Utah station on relationships between live and dressed grading of chickens. The study showed that there was considerably more variation in the practices of poultry buyers than there was in the prices offered farmers. Eighty-five percent of the Leghorn hens were classed as first grade on a live basis, but only about 66 percent of the samples of first-grade hens were Grade A on a dressed basis according to Federal standards. This means that only about 56 percent of the Leghorn hens in the State would actually meet Federal standards for Grade A when dressed, although 85 percent are graded A when alive.

Marketing and Handling Practices

Marketing and handling practices have an important influence on volume of sales, market losses, efficiency of operation, net returns, market outlets, and the success or failure of those engaged in growing and distributing agricultural commodities. Farmers, their marketing cooperatives, and other handlers constantly seek ways to improve their practices. Competition is keen; and unless the goods, many of them perishable, are handled with efficiency, it is difficult to stay in business. Avoiding waste through inefficient handling is particularly

important during a period of defense mobilization. Examples of station research that have improved handling practices follow.

Washing and waxing sweetpotatoes

Observations on customer reaction in the purchase of sweetpotatoes at the retail market, made by the Georgia station, showed that there is practically no difference in the acceptance by customers of washed and waxed potatoes. Customers selected potatoes from both bins in about equal proportions. On the other hand, few customers selected brushed sweetpotatoes, preferring the cleaner potatoes in the washed and waxed lots. Losses from waste and spoilage were greatest at the beginning and end of the marketing season when less care was given to washing and waxing. The report also showed that there has been an increase in the percentage of the sweetpotato crop that is washed and waxed. In 1951 many of the larger retailers were paying a premium of 50 to 75 cents per bushel for washed and waxed sweetpotatoes.

Cutting losses in grading and packing

The Vermont station made time and motion studies at 13 Vermont apple-grading and packing houses. These included operations utilizing machines for sorting and sizing as well as those which do the entire job by hand. Sketches were drawn to show equipment layout and the direction of flow of apples. Each worker was clocked with a stop watch for periods of 15 to 30 minutes to determine the time required to accomplish the job or jobs assigned, and also the amount of time spent in idleness or waiting for work. The type of equipment used in each step of the operation, and the method employed by the individual workers in performing this job were compared.

Plants using machines to sort and size apples generally showed higher output per time spent than those which did the entire job by hand. Costs per box of packed fruit were subsequently lower in the machine-equipped plants. The time requirements for each job varied among the plants. None of the packing houses studied showed efficiency in all the jobs involved and the study showed that some improvement can be made in each. Apples were inspected to determine the amount of bruising that occurred during the grading and packing. The data growing out of the study are being used by the Extension Service and the Vermont Horticultural Society in encouraging growers to improve their handling practices.

Supplying the home market with fruit

The Utah station (coop. USDA) reports that expenditures by Utah families for all kinds of fruit about doubled as family income rose from less than \$2,400 per year to over \$6,000. As expenditure for fruit was doubling, income increased by five times. Oranges accounted for about 20 percent of the consumer's fruit dollar; all of the citrus fruits and bananas accounted for about 55 percent. Utah-grown fruit accounted for a very small proportion of the total fruit consumed under this study. On a per pound basis, oranges were the most important fruit in the diet and apples second. The study definitely shows that there is an opportunity to sell a greater percentage of the fruits produced in Utah in Salt Lake City and the Intermountain area than is sold at present. The present practice is to export Utah fruit and to import competitive and similar fruits from other areas.

North Carolina milk supply

In a dairy products marketing study the North Carolina station learned that to reach an economic balance between annual supplies and requirements, adjustments in purchase and pricing practices would have to be made. Level of income, background of experience, age, and geographic section appeared to be factors which were very closely associated with levels of consumption. Hauling rates were high because costs were high. The high costs were largely due to a very small volume of milk assembled per truck mile of route. Increasing volume per truck mile would reduce costs.

Poultry production shifts follow market trends

The North Carolina station studied the relation of shifts in poultry and egg production in the State to market influences. From 1939 to 1949 broiler production increased from 3,700,000 birds to 21,943,000 birds. This rapid increase in production was in response to an increasing demand for poultry meats. Research and extension work helped more farmers to learn how to grow broilers at a profit. Annual average prices paid to producers have been rising, but the rapid response in output has kept rises at a lower rate than would have occurred otherwise. This adjustment to broiler growing in North Carolina has taken place in areas where alternative incomes from cash crops are relatively low.

Egg production in North Carolina in 1945-49 was 56 percent greater than in the period 1926-30. In 1944, about 83 percent of the 287,412 farms in North Carolina produced eggs, but only 5,696 farms were classed as poultry farms. Seventy-three percent of the flocks and 39 percent of production took place on farms with from 1 to 49 birds, whereas only 1.8 percent of the flocks contained 200 or more birds and produced 21 percent of the total output. Although egg production is a highly decentralized enterprise in North Carolina, considerable progress is being made in seasonal adjustments in production. Fall output of eggs compared with the spring output has increased from 29 percent in 1926-40 to 41 percent in 1946-49. This is largely a result of changes in the rate of lay per bird during the fall.

Marketing Puerto Rico bananas

The Puerto Rico station is seeking to improve the handling of bananas shipped from the island to the continental United States. Four tests were made, using the Monte Cristi variety of bananas, under refrigeration and without refrigeration. It was found that a temperature of 40° to 42° F. chills the bananas, making them unfit for ripening. A temperature of 64° maintains the bananas with a green-colored skin for a period of 10 to 12 days, after which banana stems bearing fruit of full-three-quarters and light-full-three-quarters maturity stages start to ripen with a yellow, golden color in the skin, although uniform ripening on the whole stem is not obtained. Fruit with a maturity stage equivalent to three-quarters-grade does not ripen even after 15 days' exposure to a temperature of 64° and the use of ethylene gas may be required as a ripening stimulus. The relative humidity during exposure to the 64° temperature should be kept between 90 to 95 percent at all times. Fruit exposed to temperatures of 80° and above will not ripen with a yellow-colored skin.

In its study of the effect of handling and transportation methods on the quality of the bananas, the Puerto Rico station concluded that

inefficient methods of transportation are used by the farmers on their farms and by the middlemen who buy the bananas at the farms and take them to the markets. These methods cause considerable scarring and bruising of the fruit in transit from farm to market. The use of padded trucks or special vans adapted for transportation of fruit to be exported or locally used for ripening purposes was recommended.

Sale of frozen eggs

The Alabama station studied the possibilities of freezing eggs in individual containers with the yolks unbroken for resale through retail channels. A package 2.6 cm. \times 4.0 cm. \times 4.0 cm. in dimension kept dehydration of the yolk to a minimum and was the best-sized package for a single standard-sized egg. Tests of many packaging materials disclosed that pasteboard boxes lined with waxed paper were the most desirable from the standpoint of quality of product and attractiveness. The best quality eggs were obtained when they were frozen at 23° F. Sample packages of frozen eggs wrapped individually in waxed paper were distributed to 10 Auburn homemakers to test consumer reaction; 8 of the women preferred them to the shell eggs they were buying from stores, although they objected to the inconvenience of having to thaw the eggs.

Egg grade procurement program

The Illinois station (coop. USDA) made an analysis of a southern Illinois egg-grading operation from 1947 to 1949. This analysis substantiates previous results of grade procurement studies in northern and central Illinois. Farmers received an average of 6.3 cents more by selling on grade rather than on a current-receipt basis and the average quality of eggs was better. Farm deliveries increased 474 percent in the 3-year-period. A fourth-year analysis of the practices of one of the original cooperating firms in the study further substantiates the fact that farm people respond well to a grade procurement program, where they receive incentives to produce quality eggs.

A study of four western Illinois firms further indicates that during the flush egg season, the best market outlets for most western Illinois eggs are the egg breakers and dryers. In the short season, best outlets are in the Southern States. These firms report that western Illinois eggs can be taken to Iowa or Wisconsin and shipped from these points and sold (not as Illinois eggs) at a premium over what they can get by selling them as Illinois eggs.

A few off-grade eggs will down-grade dozen lots

The Rhode Island station found that eggs are stored in the cellar on a majority of farms. Little relationship existed between quality and temperature and humidity. All farms reported that they cleaned eggs. In the winter 86 percent of the eggs were Grade A and above and 76 percent in the spring. There was no significant relationship between egg quality and the kind of practices followed by producers. Three-fourths of the stores displayed eggs under refrigeration. Of all dozen lots studied 85 percent were classified as falling below the grades represented and 34 percent below the dozen-lot size represented. The large proportion of off-grade dozen lots was the result of a wide distribution of a small number of off-grade eggs. On an individual basis, the regrading showed 80 percent of all eggs to be Grade A or above, 10 percent Grade B, and 10 percent Grade C—stained, dirty, cracked, or loss eggs.

Marketing Facilities and Equipment

Considerable opportunity for lowering marketing and distribution costs lies in the installation of efficient facilities and equipment. Very often at the request of individual growers or grower organizations, and frequently in close cooperation with industry, experiment stations undertake research along these lines. Although actual improvements in machinery and buildings are the job of the agricultural engineer, marketing specialists very often are called upon to serve as close collaborators.

Commercial seed-processing plants

Extensive studies of commercial seed-processing plants deal with design of buildings, the necessary machines for processing different seed crops, the selection of machines of proper size and with the proper attachments, and the arrangement of machines and equipment in the plant. This information has been used in the design and construction of an experimental seed-processing plant at the Mississippi station and for other commercial plants in the State. The processing machines necessary for a given seed plant depend on the volume and kind of seed to be handled, methods of harvesting, climatic conditions, and noxious seed in the mixture. The most common machines found in seed-processing plants are the fanning mill, disk separators, spiral separators, scarifiers, dodder mills, and gravity separators. The size of machines, bin capacities, arrangement of spouts, and the location of elevators and other machines should permit the passage of seed from one machine to another mechanically. In the study of a number of commercial seed plants, it was found that there was no definite plan for the building and arrangement of machines and equipment. Most of the buildings were two or more stories in height and made use of bucket-belt elevators.

Fluid milk distribution

The Alabama station collected monthly data on supplies of fluid milk, by sources, and sales of fluid milk products for the years 1947-49. The information shows that Alabama farmers, in recent years, have been selling mainly to fluid markets. In 1949, more than three-fourths of the whole milk sold went into these channels. Although sales of fluid milk have been increasing, local supplies of bottling milk have expanded more rapidly and by 1949 were approximately adequate, in most markets, to meet needs even in the fall of the year, when supplies were most limited. Milk distributor operations were studied in cooperation with the State Milk Control Board. Data from 35 plants showed that most distributors realized only small profits and others incurred losses. Large operators generally fared better than small ones because they handled proportionally larger quantities of byproducts and had facilities that were better adapted to fluid milk needs. The study points to the need for greater emphasis on improving market facilities.

Storage for Arkansas soybeans

The Arkansas station (coop. USDA) made a study of the location, type, amount, and characteristics of storage space available for soybeans. On-farm storage was available for 4,150,000 bushels; storage at country elevators and buying stations for 2,482,800 bushels; and a

5,500,000-bushel capacity was available for soybeans at oil mills. In light of the present acreage of soybeans grown in Arkansas, the station found present facilities fairly ample.

Planning a modern produce market

The Davidson County (Tennessee) Marketing Commission requested the Marketing Facilities Branch of the Production and Marketing Administration, USDA, and the Tennessee station to obtain data that would assist the Commission in planning a modern public wholesale produce market for Nashville and its trade area. A survey was made of produce dealers and truck farmers in the surrounding territory to determine the extent to which they made use of the Nashville market. A survey was also made of retail stores in Nashville to determine the marketing channels through which they obtained produce. A county-wide referendum authorized a bond issue of one million dollars for this market. Overbuilding and unsuitable construction at an improperly selected site could conceivably have run up a big financial loss. The survey provided information for careful planning of the market and prevented unwise use of public funds.

Marketing Functions

Assembling, transporting, grading, packaging, processing, storing, financing, wholesaling, and distributing comprise the principal tasks in marketing; and most of the problems in marketing focus around these tasks. Much marketing research carried on by the State experiment stations is directly related to the various marketing functions necessary in moving farm products through the various channels of trade to their final destination.

Merchandising large turkeys

The Nevada station (coop. USDA) undertook research to find better market outlets for the large-type broad-breasted turkeys grown in the State. It was found that consumer reaction on five retail markets was almost unanimously favorable to purchase of cut-up turkey meat and that market operators were receptive to the idea of handling the cut-up turkey. The volume handled, however, was small, probably because of the relatively high prices charged. A survey of sales of large-type turkeys to patrons of frozen-food locker plants and owners of home-freezer cabinets in western Nevada was also undertaken. The returns revealed a substantial demand for turkey meat for home-freezer and locker-plant storage, provided abundant supplies could be obtained at moderate prices. These studies show how large turkeys may be merchandised more economically in comparable market areas to the advantage of both producers and consumers when cut-up turkey is sold in retail markets and frozen turkey is available in locker plants, home-freezer cabinets, and in retail self-service departments.

Vegetable packaging costs

The Florida station (coop. USDA) conducted research on the cost and efficiency of packaging vegetables. The selling prices and harvesting, packaging, delivery, and selling costs were obtained for 218,429 cartons of prepackaged vegetables. Packaging costs were 30 percent higher for sweet corn, 45 percent higher for cauliflower,

and 129 percent higher for broccoli when prepackaged than when packed in bulk. Selling and transportation costs were less when prepackaged. Wholesale prices, delivered, and the gross returns to the grower were higher for prepackaged sweet corn and cauliflower than for the same original quantity in bulk. Package ventilation was found to be critical for broccoli except at 35° to 40° F. Celery, commercially stretch-wrapped in pliofilm or packaged in cellophane bags, arrived on northern markets in good condition. Wilting was prevented by prepackaging at the source.

To determine the extent of transit injuries, 164 test lots of tomatoes were shipped by the Florida station in 5 types of containers in comparison with the standard lug. Eight truck and two rail shipments were made to northern markets. Injuries were most serious in the open field box—17.2 percent by rail and 8.3 percent by truck. The nailed, T. A. B. wirebound, and small Spartan were the best containers in trucks, with less than 3-percent injury. In the rail tests, injuries in all containers were higher than in trucks, the lugs had the least injury—9.5 percent. Some f. o. b. prices were higher for tomatoes in lugs than in field boxes or wirebound crates. Returns to the grower were usually greater for the larger containers because of higher packing costs in lugs. Total labor cost was only 63 percent as much for field boxes, and 77 percent as much for nailed boxes, as for lugs. Time required to wrap and place-pack lugs averaged $3\frac{1}{2}$ times as much as to jumble-pack the same quantity in bushel boxes.

Marketing prepackaged apples

Prepackaged apples outsold bulk offerings of apples whenever the prepackaged ones got comparable display space, according to a study conducted by the Ohio station. The station contacted producers for information relative to their methods and cost of prepackaging. The station also contacted grocery stores that handled apples from the producers who had supplied the prepackaging information. Likewise, retail customers who purchased the prepackaged apples were interviewed to obtain their reactions.

The survey showed that very little mechanization was being used by the growers in prepackaging since most of them felt no practical machines were available for such work. Cost of prepackaging ran from about 30 to 75 cents per bushel, the largest single cost item being usually for the bag. Consumers generally liked the type of package in which all apples could be seen and considered the 4- and 5-pound packages not too large.

Transparent overwraps for tree-ripe peaches

The Georgia station, after testing the several transparent overwraps available for prepackaging tree-ripe peaches for the retail trade, showed that it is absolutely necessary for the packages to be vented under all temperature conditions. Refrigeration is necessary if the peaches are held for a very long period; however, it may be dispensed with, if the prepackaged peaches are moved only short distances and are not held for very long periods. Peaches reaching a high stage of maturity on the tree, packaged in consumer packages and moved rapidly through the marketing channels, should give the peach industry in the State a higher yield, more popular consumer acceptance, and a higher unit price.

Market returns for wool

Seven experiment stations (coop. USDA) are active in a regional study on the preparation and processing of domestic wools. The objective of the study is to develop methods by which wool growers may obtain higher market returns. Records kept by the Wyoming station showed that in the 1950 shearing season 448,378 pounds of grease wool were taken from six major Wyoming clips prepared for market. In general, the station's study showed that the visual grades (made by the commercial grader) conformed in fiber diameter and staple length with the standard grades; yearling ewe wools tended to measure finer in diameter than they had been graded; visual estimates by graders of fiber fineness and grade length were relatively consistent throughout the grading period; and shorter wools in the quality grades were found to be finer than staple wools of the same quality. Many wool growers are learning how to prepare their wools for market by detagging and grading for length and quality.

The Texas station studied the grading of wool at shearing pens in the Sonora area and made a survey of the Texas wool and mohair grading system. A total of 1,249,809 pounds of graded wool checked by the station consisted of the following: Fine staple, 48.1 percent; fine French combing, 28.9; fine clothing, 12.3; and tags and clippings, 10.7 percent. Price data were complicated by the fact that the wool was sold on different dates during the upswing of wool prices to the highest on record. In addition the information for the study was obtained from 88 Texas wool and mohair warehouses. Wool growers have followed these studies with increasing interest and as a result of them are now taking greater care in preparing wool in order that they may obtain a better price for it on the market. Selecting sheep that produce better than average staple length wool has been shown to be profitable.

The New Mexico station found that fine ram wool is as good for making tops as fine ewe wool; that tags and short fine heavy shrinking wool give greater profits when sold as scoured wool; and that body weight, wool length, and wool volume are associated with clean yield. These are reliable measurements when used for estimating shrinkage of wool. Grading clips of uniform fineness was profitable except when graded lots were under 5,000 pounds.

The Montana station accumulated, sorted, and scoured 31,058 pounds of preshearing clippings and shearing floor off-sorts. The sorts were sold on a scoured wool basis. The off-sort wools returned the growers from 12 to 18 cents more per pound where sold separately than when offered at the time of selling the wool clips.

The Oregon station studied grading of wool at the shearing shed. Where possible the clips were followed through to the mills to learn whether or not the grading was satisfactory. It was found that the fine and half-blood grades were purchased by eastern mills and the coarser grades by mills in Oregon. All of the mills reported that the grading of wool delivered to them was satisfactory.

The Utah station tested the grading of wool at the shearing shed and in the warehouse to determine the feasibility and cost of grading in preparation for marketing. The station concluded that wool can be satisfactorily graded at less cost at the shearing corral, when large numbers of sheep are involved, than at the warehouse, largely because fewer bags are used. Cost of grading at the shearing corral was

about 0.25 cent per pound and at the warehouse approximately 1.1 cents per pound.

Cannery capacity in Louisiana

A study of commercial fruit and vegetable canneries is being continued by the Louisiana station. In 1950, 22 plants in the State packed 1,533,447 cases of products valued at more than 4 million dollars, an increase of 51 percent in volume and 61 percent in value over 1949. Sweetpotatoes comprised 72 percent of the pack, followed by okra and green beans. The short operating season is the major factor affecting plant efficiency. A large amount of unused capacity is available in the State should it be required during the mobilization period or in case of war.

Hauling and transporting sugarcane

A survey made by the Puerto Rico station showed that if motor trucks are to be used profitably in transporting sugarcane from the farm to the mill, the mills will have to provide better facilities. According to the station's findings a better correlation is needed between the tonnage assigned to each grower for daily delivery and the capacity of the mill. Also there is a tendency to use too many trucks.

New cigar binder market reporting

The Storrs station (Connecticut) sought to develop better methods for marketing Connecticut Valley types of cigar binder tobacco. It devised new market reporting procedures that were tested on the 1950 binder markets. Techniques for sampling bundle tobacco in order to estimate quality grades in individual crops were designed and tested. A practical sampling procedure will help farmers appraise their individual crops more accurately and will help to develop a system of more efficient marketing. Fifteen cigar manufacturers in the Northeast were interviewed to secure data on grade characteristics of binder tobacco and how such grades are defined. This information was used to appraise the relative values of different quality tobaccos and to improve present grade standards.

Receiving, storing, and shelling peanuts

A study of the alternative methods of performing the several functions involved in receiving, storing, and shelling peanuts is now in progress at the Georgia station. A comparative cost study was made of unloading by different methods. The most economical methods, the study showed, are the pneumatic lift, the dump pit, and the bucket-elevator systems.

Carbon air purification

A commercial activated carbon air purification unit tested out in a 10,000-bushel refrigerated apple storage plant in northern Indiana in the season 1949-50 did not retard the softening or ripening of apples. Tests were conducted by the Indiana station during the 1949-50 season. Storage scald of Stayman Winesap apples was reduced, probably as the result of removing the volatiles by the activated carbon. No scald developed in Grimes Golden or Rome Beauty apples in storage, either with or without air purification. The use of shredded oil paper in wrapping apples gave excellent control of storage scald on Stayman Winesap apples in storage both with and without air purification.

Storing and handling potatoes

Farm and commercial storages, 71 in New Jersey and 28 on Long Island, were included in a 1950 field study of storage and handling facilities for potatoes. The New Jersey station found that there was a general lack of understanding by growers of the necessity for proper ventilation and insulation in storing. Condensation frequently caused early sprouting and premature failure of structure in storage. Weight losses were observed in eight 2-ton samples of Katahdin potatoes in five storage houses. Ventilation system design, management, and storage period, were the greatest single factors influencing weight loss. Losses in well-ventilated storage were no greater than those in refrigerated storage. Use of sprout inhibitor was not justified in well-ventilated storage. A fan capacity of 1 cubic foot per minute for each 150 pounds of potatoes is needed to hold the temperature at 40° F. in below-ground storage with thermostatically controlled ventilation and recirculation.

Market Losses and Spoilage

Losses and spoilage incurred in the marketing of perishable products are still among the problems faced by producers and handlers even though in recent years research has developed many improvements in marketing facilities, equipment, and handling methods. Spoilage losses in marketing have a definite effect on net returns to producers, consumer acceptance of products, costs in handling, and margins charged. In some instances they make up the difference between profit and loss on the part of retailers.

Shipping early potatoes

A regional research project supported by five southern experiment stations (coop. USDA) is seeking ways to reduce losses in marketing early potatoes. Approximately 30 percent (by volume) of the early potatoes shipped to northern markets may be charged off as spoilage, according to the South Carolina station. The spoilage loss varies according to variety, methods of transportation, temperature en route, and similar factors. A very high percentage of the total spoilage was traceable to "minor" injuries. Visits were made to four commercial potato areas in South Carolina during the marketing season in order to observe the harvesting and grading process, and test lots of potatoes were taken from farms in these areas and were examined for mechanical damages. Wherever possible, damages were traced to the part of the machine or operation responsible. The information obtained is being used in setting up alternative methods of handling potatoes that will reduce physical damage.

Controlled shipping tests were conducted by the Alabama station to learn the effects of transporting washed but undried early potatoes by ventilated vans and open trucks that made limited use of tarpaulins. Data obtained on seven test loads between Summerdale, Ala., and Chicago, Ill., showed that potatoes transported by van contained a slightly higher percentage of soft rot and a much higher percentage of sticky scale upon arrival than those transported in open trucks. Potatoes transported by open truck were affected to a much greater extent by scald and browning and after 1 week had a higher percentage of all defects. The loss of weight in transit averaged 2.2 percent when

shipped by van and 6.5 percent by open truck. An approximate loss of \$65,000 would result from shrinkage in the total quantity of potatoes shipped by truck from Baldwin County, Ala., in 1950.

The Florida station reported that the paper bag is the principal type of container in which potatoes from Dade County, Fla., are marketed. Potatoes packed in a paper bag lose heat slowly because of its insulating value and the lack of air circulation that results from the way the bag is usually loaded. Some shippers have begun to use bags perforated with eight or twelve $\frac{3}{8}$ -inch holes in an attempt to get better temperature and moisture control. In 1950, growers in the area also began the practice of waxing and coloring potatoes to improve their appearance.

Two special tests were run on railroad cars loaded with both perforated and nonperforated bags, in shipments from Princeton, Fla., to Chicago and Cleveland. The purpose was to learn what effect the perforation of paper bags had on heat retention and what the loss in weight would be in transit and bag breakage.

Tests conducted to study the effect of waxing potatoes on spoilage and weight loss in transit showed that temperatures in perforated bags were slightly lower than in nonperforated bags. The difference was very slight and not enough to affect decay. The potatoes in perforated bags lost slightly more weight in transit. No important difference was found in weight loss or decay as between waxed and nonwaxed potatoes, either in transit or on holding.

Harvest bruises increase later losses

A study on potato losses conducted by the North Dakota station (coop. USDA) indicates that although the bruises that are noticeable immediately following harvest may often be serious, many do not become apparent until the potatoes have been in storage for a considerable period. In fact, less than half of the results of bruising injury are apparent immediately after harvest. Results of the study have been given to growers at public meetings. Taking advantage of the information developed in the study, the Red River Valley Research Center operated by the growers association in the Red River Valley area, has put into operation plans for improvement in methods of harvesting and handling the Red River Valley crop.

Growing methods and tomato market quality

A survey made by the Tennessee station (coop. USDA) of 130 commercial tomato producers and 19 packer-buyers of tomatoes in western Tennessee, shows that there is a direct relationship between certain production practices and the marketable yield and quality of tomatoes. It shows that by using quality standards, by proper handling, and by effective control of insects and diseases through practices approved by the State station, growers could have increased their yields about 44 bushels per acre in 1949 and 46 bushels per acre in 1950. For the 3,119 commercial tomato producers in the area growing 3,200 acres of tomatoes in 1949 and 3,000 acres in 1950, the cash value of increased yields would have amounted to \$66 per acre in 1949 and \$181.47 per acre in 1950.

Preserving eggshell quality

The effect of cleaning and shell treatment on eggshell quality was studied by the Ohio station. It was shown that cleaned eggs will not

keep as well as the uncleaned ones. Eggs cleaned by washing kept as well as those cleaned by dry methods. The longer the cleaning was postponed the better the eggs kept. Eggs cleaned with a combination of detergent and germicide kept better than those cleaned with water alone or with a detergent. The functional properties of eggs were not harmed by soaking them in detergent germicide solutions at the time of cleaning. The keeping quality of cleaned eggs was greatly improved without injury to their functional properties by agitating them in water at 144° F. for 2 minutes. Oil-soluble or dispersed fungicidal and bactericidal agents reduced spoilage of eggs dipped in contaminated egg-treating oils, and the decline in quality of eggs was greatly retarded by dipping them in oils containing waxes and in plastic film-forming compounds.

Marketing Maine apples

The Maine station studied the quality of apples offered for sale in the Portland market. The information compiled to date points to certain improvements Maine growers should make if they want to enjoy full advantage of the market. Better grade standards are needed. The quality of other fruit offered for sale in the stores visited was better standardized than apples. A definite need exists for containers that will protect the apples from bruising and also display them to a better advantage in retail stores. Of the five containers used in the shipments of McIntosh apples from the farm to wholesale and retail establishments in Portland, apples in the layer packs showed considerably less bruising than those in the jumble pack. Similar results were obtained when McIntosh apples were shipped to distant markets by express.

To ascertain the relationship of the extent of bruises to volume of apple sales, one lot of McIntosh apples was placed on display in each of two retail stores in Portland. At 2-hour intervals throughout the day for a 5-week period, the displays of apples were examined for bruises and the quality of apples sold recorded. When the bruised surface area amounted to about one-fourth of a square inch per apple, retail sales averaged 12.2 pounds per hour. When bruises amounted to about one-half square inch per apple, sales averaged 9 pounds, and when bruises were nearly three-fourths square inch per apple, sales averaged 8.8 pounds.

Shipping and dry-lot shrinkage of calves

The Wyoming station reports that overnight shrinkage of range calves averaged 4.1 percent when cut off from their mothers and native range pastures and kept in a dry lot from 12 to 15 hours. The kind of pasture to which calves had had access seemed more important than the distance they had been hauled or the time elapsing between weighings. Native grass pasture calves hauled 90 miles in 5.5 hours shrank 3.5 percent, whereas soft grass (irrigated) pasture calves hauled 85 miles in 3.5 hours shrank 8.2 percent. Trucking calves the relatively short distance of 85 miles resulted in nearly as much shrinkage (3.7 percent) as keeping them for 12 hours on a dry lot (4.1 percent). Shrinkage was greater on heavy steers off from range grass (7.6 percent) trucked 250 miles in 11 hours than from those out of a feed lot (5.7 percent) hauled 2.5 miles in 12 hours. Both lots were held on feed and water for 10 hours before sold. Evidently

the fat steers were more accustomed to feed-lot conditions and probably took on a greater fill and regained some of the weight lost in transit.

Development and Expansion of Market Outlets

Agricultural producers and handlers are alert to the possibilities of developing and expanding market outlets for their products. However, to undertake a sound expansion program requires a considerable amount of scientific information if the industry is to avoid "stumbling blocks" or failure due to misdirected investments. It is for this reason that grower organizations and many groups interested in the processing and marketing of farm commodities frequently request research to develop the basic new information required.

Vending machines for fluid milk

A business analysis of milk-vending machine operations made by the Wisconsin station shows that widespread use of the machines, which are similar to those now used for soft drinks, candy, and cigarettes, could create a new outlet for about 510 million pounds of milk over the country each year. This is a conservative figure as the total amount of milk that could be sold in vending machines would be about 2,520 million half-pints yearly. Not all of that would be new business. Some would replace over-the-counter sales and home deliveries. The new business could reach as high as 945 million half-pints yearly. Some of this increase would be due to the lower price and added convenience of buying milk from machines and some to the substitution of milk for soft drinks. Because it is perishable, milk has to be handled more carefully than many products sold in this manner. The milk dealers should be the logical vending agencies and the dairy industry should be interested in the whole program.

Market prospects for sesame

Because data obtained in a 7-year agronomic study of sesame conducted by the Nebraska station indicated commercial possibilities for the crop, a detailed survey to determine its market possibilities was undertaken. The survey showed that Nebraska stock feeders could use several times more sesame oil meal than is available. Opportunities also exist for expanding the use of sesame meal in human foods. Sesame oil, because of present high prices, is being used only in drugs and insecticides, where other oils cannot be readily substituted. As the use of sesame oil expands to the edible field, price differentials would become smaller. Without exception, commercial users are interested in a domestic supply of seed and oil. Sesame oil is desirable because of its ease of processing, flavor, and stability.

Market survey in Alaska

The Alaska station made an economic study of potential markets for agricultural produce in the territory. Information concerning the nature and adequacy of present marketing, processing, storage, transportation facilities, and services was brought together and analyzed, to aid farmers and prospective settlers in planning desirable improvements. The study is the only current research providing vital background information on marketing and possible new marketing alignments in Alaska. Potential production and marketing prospects of

agricultural products of the Kenai Peninsula area were examined critically to determine their logical place in Alaska's agricultural economy.

Marketing pork and pork products in Europe

The Minnesota station (coop. USDA) is conducting research on methods employed in Great Britain, the Scandinavian countries, and Western Europe, in the marketing of pork and pork products. A study made in England involved interviews with meat packers, dealers, some consumers, government officials, and representatives of agricultural colleges relating especially to the demand for pork and pork products. Marketing and processing methods were studied in some countries which sell to England, including Ireland, Denmark, Sweden, and the Netherlands. Hog marketing and pork distribution methods were studied in Norway, Belgium, France, Western Germany, and Italy. The overseas study brought the station into more direct touch with European marketing problems, methods, and outlets, and established contacts for the United States with major developments affecting foreign markets for farm products.

Live poultry in Chicago wholesale markets

An analysis of Chicago Poultry Board inspection certificates of receipts of live poultry for 1948 and 1949 was made by the Illinois station (coop. USDA) to determine the origin, seasonal movement, and relative importance of supply areas for live poultry on the Chicago wholesale market. During the period studied 17 States supplied this market. Greatest shipments in 1949 were from Illinois, with 40.6 percent; Iowa, 17.1; Indiana, 14.5; Arkansas, 12.6; and Wisconsin, 6.8 percent. Arkansas shipments dominated the market from January through May, about 40 percent of the total. Indiana led in June and July. Illinois, Iowa, and Wisconsin market movements were greatest during the latter half of the year. Arkansas and Indiana broilers caused heavy seasonal receipts.

Marketing limitations affect conservation of forests

The Mississippi station reports that timber marketing is a critical part of the process of forest resource conservation. There are many imperfections in the marketing system. The situation is particularly critical in the 17 northeastern counties of Mississippi, where the forest stands are already badly depleted and are going down twice as fast as in other parts of the State, in spite of the fact that forest acreage is increasing as a result of the abandonment of worn-out farms and a decreasing population. Most of the forest land is in small, nonindustrial ownership. There is a dearth of market outlets for all forest products except sawlogs and a prevalence of small mills exploiting the remaining timber without regard to the future.

The station is making a problem analysis designed to get a detailed, accurate picture of the marketing system and to suggest imperfections which might be corrected through further research. Marketing imperfections cited are: (1) Too small production for efficient marketing; (2) low quality product; (3) inaccurate and unstandardized measurement and description; (4) lack of knowledge of products and outlets by sellers and buyers; (5) minor position of timber in the individual businesses of many owners; (6) owners' and buyers' insecure

financial status; (7) wasteful handling; and (8) lack of integration in marketing and processing a variety of forest products.

Potato acreage and production trends

The Maine station, in a survey of shifting potato acreages, found that there is a tendency for production to shift to higher yielding States and to higher yielding areas within States. These shifts contributed substantially to the increases in average yield of potatoes per acre for the country. Under present production methods, where operations are performed by mechanical devices, these shifts in acreage result in reduced costs of producing potatoes, part of which is passed on to the consuming public. Government price support for potatoes from 1943 to 1949 has probably brought about a substantial increase in the average annual production of potatoes because the price was sufficiently high to encourage production in favored areas of potato growing.

Detailed information was obtained this year from over 400 Maine commercial potato growers concerning the effect of farm potato acreage reduction on the per barrel costs of producing and marketing the crop. The information is of practical value to potato growers, shippers, and the entire industry in indicating changes now in process, as well as probable future changes. Commercial potato-producing areas are concerned with these changes, because each production area is in competition with others and also because of the probable future effect on the size of potato farms. The information is also essential in establishing potato goals and in formulating Government policy and programs.

Market Prices

Good judgment and intelligent appraisal of market prices, price swings and trends, and an understanding of the influences that bring them about, will help the farmer to keep from "going in the red" in his farming business. With modern reporting services, such as trade and market journals, the farm and daily press, and daily radio broadcasts on sales and prices, farmers have many sources of spot information to help them keep up with seasonal, weekly, and daily price developments. They also have the annual outlook reports and monthly situation reports issued by USDA's Bureau of Agricultural Economics, interpreted in the States by economists, and made available locally by the county extension agents. These services are generally interwoven with economic research at the State experiment stations, particularly in research on agricultural prices.

Using farm resources in relation to prices

The North Carolina station is making a study to determine trends in the use of agricultural resources on individual farms in the southeastern region. Alternative ways of using farm resources under various assumptions with respect to relative prices from different agricultural enterprises, off-farm employment, possible price support, and acreage allotment proposals will be evaluated. Methods and costs of moving from present farming systems to alternative systems will be developed.

California citrus-pricing study

California economists (coop. USDA) have conducted a complete survey of the citrus industry and have concluded one of the most extensive citrus-pricing studies ever made. The findings are pertinent for growers, shippers, and distributors and help them in planning shipments that result in increased returns. Retailers tend to follow a pricing policy of percentage mark-up. They also tend to base their retail price primarily on costs of the respective lot and the retail price tends to remain tied to the cost price, irrespective of the current wholesale price.

Seasonal feeder pig prices

The Kentucky station found that the important factors affecting seasonality in price of feeder pigs are (1) seasonal movement of receipts, and (2) the adjustment of farming plans with respect to purchase or sale of feeder pigs to the time of harvest, size of the corn crop, and decline in pasture availability in the fall. The seasonal price peak for feeder pigs comes in July, only a month after the lowest volume of market receipts for the year. The low price for feeders for the year occurs in December, after the bulk of fed pigs have moved to market.

Better price-making for eggs

The present method of price-making for eggs on the Boston market is not so satisfactory as the industry might like to have it, according to the Massachusetts station. The reason is that the present system ignores the structure of the market and the related trading arrangements. Its shortcomings are counteracted to some extent, however, by the close relationship that prevails between the New York and Boston prices for eggs of comparable quality and grade. The market reports, which provide the data essential for pricing, can be improved both as to coverage and content.

Pricing burley tobacco

The Kentucky station continued an analysis of the relationship of daylight conditions and price dispersions of burley tobacco. The sampling was limited to grades of 15 or more baskets. On cloudy days during December, 73 percent of the baskets were priced within \$2 of the daily grade average price compared with 62 percent on partially cloudy days. An analysis made by using company grades as the measure of quality showed that pricing was also more uniform on cloudy days. Grades of high quality and light-colored tobacco were uniformly priced throughout the marketing season. In the lower grades, the extent of price dispersions varies greatly from day to day, with less dispersion during the last part of the marketing season. The range in the percentage of baskets priced within \$2 of the daily grade average price by warehouses was from 59 to 71 percent. The better grades of tobacco were uniformly priced on all warehouses, although the prices of the lower grades varied greatly among warehouses.

Broiler supply and price trends

Computations being made in a study of market prices of broilers by the Pennsylvania station included indexes of seasonal prices, variation, measurement of the farm-to-retail marketing margin, and

various feeding ratios. The data are being analyzed to discover the extent to which changes in marketing influence prices, how prices affect expansion and contraction of production, the relation of prices of broilers to prices of red meats, and similar influences. Apparently some of the current statistics commonly followed in the trade for future supply and price trends do not have the degree of reliability usually placed on them.

Retail price influences for fruits and vegetables

The following results were obtained by the Maryland station in its study of pricing policies for fruits and vegetables in retail stores: (1) Loss due to "waste and spoilage" in three supermarkets ranged from 3.5 to 8.6 percent of dollar volume handled; (2) retailers who followed the practice of "markdown" or price reduction in order to move the supply of fresh produce incurred less waste and spoilage loss than those who did not follow this policy; (3) produce grown in Maryland and in surrounding States and sold in local retail stores did not incur greater loss than did the produce shipped in from more distant areas; (4) produce sold at retail in "prepacked" or consumer-sized units incurred only one-third to one-half as much loss as the same items sold in bulk form; (5) the demand for individual commodities in the short run proved to be relatively elastic except in stores with a relative "area monopoly," in which case the demand proved to be relatively inelastic for individual commodities; (6) the average "markup" as a percentage of retail price varied between stores and individual commodities; (7) the retail price for fresh produce averaged somewhat lower on Fridays and Saturdays, and highest on Wednesday; (8) more than 50 percent of weekly volume of sales occurred on Friday and Saturday; and (9) the retail price for individual commodities proved to be more inflexible than wholesale cost. On many commodities the retail price held constant for long periods, whereas the wholesale cost varied considerably.

Experimental corn price forecasting method

A tentative corn price forecasting method has been developed by the Illinois station. This experimental method is based on multiple graphic curvilinear correlation. Logarithms of the Illinois Farm Price of Corn were used as the dependent variable. Logarithms of disposable personal income and of the supply of feed concentrates per grain-consuming animal unit were used as the independent variables. This study was also used to illustrate the relationship between the gross value of an important farm product and the quantity available for use or sale. There was a high correlation between corn prices and the factor used. The gross value declined as the quantity increased.

Quality Improvement, Control, and Preservation

Even though great progress has been made in the past toward improving, controlling, and preserving the quality of agricultural products before and through the marketing and distribution process, much still remains to be done. Research under way at the present time presents evidence that by improving handling practices, improved treatments, more careful wrapping and grading, correct storage

methods, and better use of moisture and temperature control, further progress can be made in solving marketing quality problems.

Discoloration of wrapped poultry

The effect of wrapping material and storage time on discoloration of the flesh of poultry around the long bones and of the long bones themselves, was studied by the Louisiana station. Aluminum foil and a combination of cellophane and wax paper wrapping were superior to butcher paper in preventing freezer burn and discoloration. The discoloration scores on these tests were not appreciably different from scores on other tests in which other methods of packaging were used. Slight discoloration is present in fryers held without freezing for 24, 36, and 48 hours. There is a slight difference between sexes in degree of discoloration—females exhibit less discoloration than males. There are indications that cooking increases the degree of discoloration, but no differences exist between the discoloration of frozen cooked and thawed cooked tibia and femur.

Quality of Texas turkeys

Quality measurements were made on 145,192 processed turkeys in 5 Texas local dressing plants. On the basis of U. S. Grades, 78 percent of all carcasses qualified as Grade A, 17 percent as Grade B, 4 percent as Grade C, and less than 1 percent were rejects or no grade. Of those graded B and C, 35 percent had bruises, 26 percent were poorly fleshed, 13 percent had torn areas, and 4 percent had pinfeathers. The study proved that the quality of Southwest turkeys are equal to those from any other surplus turkey producing area in the United States.

Egg handling influences quality

Eggs obtained from each of 22 farms each month for 1 year were used by the Michigan station in a marketing study on production and egg handling practices, temperatures and humidities of egg holding rooms, and candled and broken out quality of new-laid and day-old eggs. Egg quality declined seasonally from fall to summer. Blood and meat spots increased with an increase in the age of birds. Shell quality declined with age of birds. Differences in new-laid egg quality were attributed to breeding. Decline in quality was attributed to frequency of gathering eggs, method of cooling (in summer months), temperature and humidity of egg rooms, methods of cleaning, and frequency of marketing. Although no one egg-cleaning method resulted in highest or lowest albumen quality of eggs measured, the farmers who brushed eggs marketed a higher percentage of Grade A eggs than those who washed eggs. Eggs held under highest temperatures declined in quality the most every season, even though temperature differences among farms were not consistent nor great. Eggs held under highest relative humidities lost the greatest amount of albumen quality during the first 24 hours.

A Washington station marketing study showed that the quality of eggs as measured by candling decreases very little during the first 7 to 10 days of the marketing period. After that it drops rapidly. Refrigeration practically stopped further quality deterioration of eggs in short-time storage, irrespective of condition of eggs when placed under refrigeration. A shortened marketing period and re-

frigeration at the assembly points are the principal means by which quality of eggs received by the consumer can be improved.

The Pennsylvania station learned that eggs generally failed to meet the quality claims of retailers in the State. Among independent and voluntary chain stores only one dozen in five offered as Grade AA, A, fresh, or with other indications of fresh as specified by the Pennsylvania Fresh Egg Law, were actually of Grade A or better quality. Approximately one-half of the dozens purchased from all stores were found to be Grade B according to U. S. Consumer Grade Standards. About 10 percent were classified as "No Grade" because of defective shells, and an additional 7 percent as No Grade because of large spots, inedibles, etc.

Other research on quality

That production and handling practices have a direct bearing on the quality and prices of apples, potatoes, sweet corn, and tomatoes was demonstrated by the Ohio station. If cultural, harvesting, handling, and storage practices were to be altered generally in line with recommendations that came out of the Ohio study, growers could add to their income and consumers could enjoy more desirable products. Sweet corn sales were almost doubled in stores handling corn which had been iced in the field and displayed on crushed ice as compared to corn handled in the usual manner. Tomatoes held at 40° to 70° F. broke down quicker and had a lower total acidity than tomatoes which had been stored at 50°. Rome Beauty apples from one location had a consistently higher rate of respiration than fruits from two other locations. Potatoes treated (pre-emergence and postemergence with 2,4-D) and untreated potatoes were harvested. No significant difference was found between pre-emergence treatments and untreated potatoes, but there was a significantly higher rate of respiration when the postemergence treatment was used, than when the potatoes were untreated.

That the rating given a stock of potatoes by store personnel does not always tally with the sales obtained for them was revealed in a research by the Minnesota station on the retail sales of potatoes. The bright, red color of the Red Warba had the highest eye appeal. Retail store managers rated it lowest in desirability because of its undersize grade of stock and deep eyes. The station reported it as the best seller. Stores were considerably reluctant about entering white potatoes in the test. When tested, actual sales of whites were not appreciably below the reds. Where customers had a choice of three grades of Red Pontiac potatoes in six stores—(1) below U. S. No. 1, (2) U. S. No. 1, and (3) higher than U. S. No. 1—the sales were about the same. This apparent absence of discrimination in buying potatoes seems to be reflected in all of the price quality studies. The housewife seems to be more price-conscious than quality-conscious. A slightly lower price on a grade caused a sharp increase in sales of that grade.

Potatoes are often subject to discoloration after peeling in the raw state and after cooking. Preliminary results obtained by the New York (Cornell) station show that there are several methods of treating tubers to prevent discoloration. Three days' exposure of potatoes to temperatures of approximately 100° F. will prevent

discoloration. A second method is to soak tubers in a weak solution of bisulfite, preferably sodium bisulfite, or to dip them in a stronger solution of the same chemical.

Considerable time was spent by the Rhode Island station in constructing a constant temperature bath and other apparatus for respiration studies in order to gain a better understanding of the physiological functions of the apple. Limited data indicate that respiration of apples is greatly reduced by dipping them in a mineral-oil emulsion. Bruising increased respiration slightly, but dipping the fruit in wax did not affect the rate of respiration to any great degree.

In 1949, 70 samples of farmers' stock peanuts were collected at random by the Alabama station in the Peanut Belt. These were evaluated with respect to moisture content, grade, and viability at time of collection and after 3 and 6 months in uniform storage. A wide variation in quality was revealed. The most important factor affecting this variation appeared to be moisture content at time of collection.

Additional feeding trials were conducted by the Oklahoma station in an attempt to discover the weed or weeds causing "skunkweed" odor in butter. It was found that cows kept in a dry lot and fed a combination of wild carrot (*Spermolepis echinatus*) and mule's tail (*Erigeron canadensis*) consistently gave cream with the skunkweed defect, which is detected by churning the cream into butter and observing the product for development of a skunky odor. A cow fed on wild carrot and freshly cut grass gave cream that occasionally showed the defect. Cows grazed on pasture that had been sprayed with a chemical weed killer produced cream free from the defect, whereas cows grazed on unsprayed pasture produced skunkweed-flavored cream.

OTHER ECONOMIC RESEARCH

Agriculture cannot accomplish what is expected of it without seeking continuously to find new and more efficient ways to use labor and material resources at hand. The various factors that affect the income and economic status of rural people, are, therefore, subject to constant study and reappraisal by the State experiment stations.

Economic research at the stations develops information that guides farmers in decisions concerning profitable management of the farm business and the most advantageous use of land and other resources in the light of changing conditions. Such research includes studies on ways whereby labor and materials can be most effectively used; on profitable crops and enterprises and their best combination according to soil and climatic conditions and location; and on financial practices most suited to farmers' needs and to minimize the risks of jeopardizing their financial position. It also furnishes guides in selecting farms best suited for the type of farming to be followed. Satisfactory rental agreements as well as forces, policies, and programs affecting farmers, and ways and means whereby farmers can use their resources most effectively to meet national needs effectively in periods of emergency as well as in times of peace, are developed. Several representative examples of results obtained through this kind of research follow.

More effective use of labor and equipment

Investigations by the Kentucky station demonstrated that types and arrangements of buildings as well as work methods have a bearing on labor costs in dairy farming. Improved work methods, building arrangements, and proper equipment reduced the labor to 75 man-hours per cow for stanchion barns. Walk-through milking areas and pole-type rest sheds with well-planned work methods reduced man labor to between 50 and 55 hours per cow annually.

The Minnesota station, in a study of the relative advantages of loose housing and conventional housing, found that a significant saving of labor could be realized through the use of loose housing. Possibilities for saving of labor depend upon the arrangements of the barns and the habits of work. A poorly arranged loose-housing barn will require more work than a well-arranged conventional barn. The New York (Cornell) station in studying the merits of pen-type dairy farming found that many of the barns could be rearranged in such a way as to make for greater efficiency in labor and a higher quality of milk.

According to the New Hampshire station, an average milker can milk cows at the rate of 3 man-minutes per cow or less, provided he follows a definite sequence, concentrates on the task, has a good layout, and culls out cows that are slow milkers. Records as low as 2 man-minutes have been made on several farms. On one farm involved in this study the farmer's wife became interested in better milking and studied the recommended sequence charts. She milked 40 cows and cared for the milk in 86 minutes. By the application of labor-saving techniques this family was able to increase the size of its herd 75 percent.

Many farmers do not operate sufficient tillable land to make economical use of their equipment. Desirable operating set-ups were recommended to Missouri farmers after the station analyzed results from an equipment study. A 6-foot combine should harvest at least 175 acres of grain, a 1-row corn picker should husk not less than 100 acres of corn, and a field baler should bale around 10,000 bales in a season, in order to maintain reasonable operating costs.

Small farms are often burdened with higher power and machinery overhead costs than large-sized farms. The New Hampshire station (coop. USDA) proved that intelligent use of custom-hired equipment under certain conditions was less expensive than owning the equipment. However, according to the Oklahoma station, the small farm operator faces greater difficulty in obtaining custom work than does the larger operator. The West Virginia station and other stations are trying to develop plans whereby custom work on both small and large farms can be carried on to the better advantage of both farmers and the owners of equipment.

South Carolina (coop. USDA) learned that the cost of operating a mechanical cotton picker varies in ratio to the field losses, grade loss, fixed cost, and variable cost. The variable costs are more constant from farm to farm than the other costs. The fixed costs are related directly to the number of acres picked; the larger the acreage the smaller the cost. A farmer with less than 100 acres of cotton will probably find the cotton picker uneconomical unless his operational efficiency is above the average. Field losses vary according to the

speed of the picker, the yield and rankness of the cotton, the variation in the height of cottonstalks, the length and contour of rows, and the amount of grass and weeds. The average field loss was 86 pounds of lint per acre. This was equivalent to about 20 percent of total yield and amounted to about \$34 per acre. Grade loss decreased as the season progressed. Similar results were obtained by the Louisiana station. The New Mexico station found mechanical picking to be slightly more expensive than hand picking. One machine would replace approximately 20 pickers.

In a study of work stock, medium tractors, and large tractors as sources of power, the Mississippi station (coop. USDA) concluded that work animals are more economical for farms with less than 30 acres of crops, but that medium tractors were the cheapest power for farms with from 30 to 60 acres of crops, and large tractors for those with 60 acres or more in crops. Guides were developed for selecting equipment and for applying ammonia efficiently and economically on crops.

The Arkansas station obtained more than 90 percent weed control by carefully combining pre-emergence and postemergence sprays directed specifically at weed infestations. The hoeing time was reduced from approximately 40 hours in the check plots to 7.5 hours on the better experimental plots. The study also showed that mechanization of the cotton enterprise had not reduced the cost of producing the cotton, but had made it possible for the farmer to operate about three times as much land.

Use of borrowed funds

The Illinois station proved to farmers that with good management, the use of borrowed funds with which to make needed improvements in farming plans was justified on land that has not been depleted or eroded beyond repair. The terms and amount of such loan should be geared to fit the individual farmer and farm plan. In the study made by the Illinois station of 116 lending agencies 109 reported very satisfactory experiences with conservation loans. A wide variation in general policies was found among the lenders with respect to length of loans, security required, and renewal possibilities. In general, if the farmer showed an interest and was working toward a definite goal, lenders appeared willing to advance funds and to cooperate in making necessary renewals until the farmer could pay off the loan. Forty-six of the lenders made these loans for 1 year or less, 12 made the loans for 1 to 3 years, and 12 for long terms (20 to 25 years). Thirty-six had a variable policy, depending upon the individual and the circumstances. During the past 5 years, 12 of the lenders have helped to finance general improvement schemes, such as new or improved drainage ditches. Indiana and other State stations are studying the extent to which the lending institutions are meeting farmers' needs with respect to funds for farm purposes.

Getting started in farming requires more cash today than it did previously. A farm now requires a larger investment in real estate, more operating capital, and is subject to greater risk than formerly. Under good management and favorable prices, however, it also is more efficient and yields greater returns. The first farm-management survey was made in Tompkins County, N. Y., in 1907. This survey has been repeated at 10-year intervals since that time. The New York (Cornell) station points to the record as evidence that the relation-

ship between farm expenses and receipts has been gradually changing. At the 1907 ratio it would have required 4.3 years for receipts and 9.7 years for expenses to equal capital. In 1947 it would have required but 1.8 years for receipts and 2.5 years for expenses to equal investment. In other words, 40 years ago a farmer could have continued to operate for a long period of time even though expenses did not equal the receipts. He could have liquidated some of his capital investments to cover expenses for several years. By 1947 this could not be done so easily. A farmer could no longer meet a large share of his expenses for a long period simply by liquidating capital.

Price of land related to distance from population centers

Distance to a center of population, industry, and trade, influences the pattern of farm real estate values in the surrounding area. The effect Ohio's larger cities have on farm real estate values was found by the Ohio station to be measurable in a radius of more than 20 miles. A smaller and flatter pyramid of farm real estate values exists around towns of smaller size. Each area tends to have its own pattern. The increase in intensity of land use, as centers of population are approached, mainly takes the form of more capital investment in buildings and in the prevalence of small farms. The increase in value of land alone is relatively small compared with the increase in value of improvements on the smaller tracts.

Combination of crops and enterprises affects returns

The principal problem that faces farmers is to select the crops and enterprises best suited to their conditions and to combine them in such a way as to obtain a maximum net return over a period of years. The experience of rice farmers in Arkansas, reflected in an experiment station study (coop. USDA), showed that, with about one-third of the cropland in rice each year, an average yield of about 50 bushels per acre can be maintained. However, with one-half or more of the cropland in rice each year, yields would be decreased about 20 percent over a period of years. Assuming these yields and 1947 prices, estimated returns to the operator would be greater with one-third of the cropland in rice than with one-half or one-fourth in rice, provided the cropland released from rice production was used for such crops as oats, lespedeza and soybeans.

In a study of southwestern Kansas agriculture the Kansas station demonstrated that careful selection and proper combination of enterprises pays. Operations must be carefully planned and the production and marketing program properly coordinated. But by following good management practices in general, farmers in the area should be able to engage successfully in several kinds of livestock production as a supplement to wheat growing, now practiced on a single-crop basis in much of the area.

Feeding practices related to prices

The Oregon station showed through research that the net cost of producing milk increased as the intensity of concentrated feeding increased and that the difference in cost between the low and medium rates of feeding was negligible. The cows responded to the more intensive feeding of the concentrates with higher production rates, but not in proportion to the higher rates of feeding. Based on the feed price relationships reported by the dairymen included in this study, 100 pounds of digestible nutrients from concentrates cost ap-

proximately \$4.75 compared with \$2.66 from hay and \$2.30 from succulence. The level of concentrate feeding should be determined by (1) the individual cow's ability to utilize the concentrates in the production of milk; (2) the price or cost of the concentrates; and (3) the price or value of milk produced.

The Illinois station made a study of practices followed from 1943-49 on 67 farms in 14 counties west of the Chicago dairy area. On farms where livestock could be kept, and where at least 25 percent of the cropland was in legume-grass mixtures, farmers were able to get almost the same total grain production and more total digestible nutrients per acre, on fewer acres. Net farm earnings were higher, rate of return on investment better, and yields were higher than on farms operated only for grain.

The Michigan station (coop. USDA) conducted a study to determine returns per acre from pasture grass. On the farms studied, the average return was \$31.90 per acre. This varied from less than nothing on some of the poorer pastures to more than \$100 per acre on the best. Lowlands mainly in Reed and canary grass were valued at \$35 per acre; rotation pastures, meadows, and Sudan grass at \$28; and native pasture, mainly in June grass, at \$13.

Woodlands as a source of income

The Pennsylvania station found that farmers following approved management practices got an average labor return of \$1.63 per hour for work performed in their own woods, in addition to the cash value of the stumpage and any profit that would have been secured if a commercial lumberman had purchased the trees removed. The woodlands of cooperators in the Pennsylvania study furnished, on the average, 2.5 hours of productive work per acre per year in harvesting forest products, not including maple sirup. The better woodlands from which the full growth was harvested annually furnished about three times this much employment.

Fewer but more satisfactory rental agreements

A study of the number and nature of rental agreements now prevailing in the State, made by the South Carolina station (coop. USDA), indicates that fewer kinds of agreements but more satisfactory ones are needed. The type of rental agreements or arrangements used varies greatly and, with the introduction of the tractor and power machinery, the number has increased. Rental agreements of 185 renters in South Carolina utilizing some tractor power were studied, and it was found that 65 variations in types of rental arrangements existed. Seventy-eight renters using all mule power on nontractor farms were found to be using 21 types or variations of rental arrangements.

RURAL SOCIOLOGY

Agricultural progress demands that we constantly improve our knowledge of how plants and animals grow. It is equally important, however, that we learn more about how rural people live, especially how they live under the great influences of change that science and technology bring about. If it takes less people to produce the food and fiber the Nation needs, what happens to those who are displaced? If our goal is the family-sized farm, what constitutes an economical unit of family farm operation under modern conditions? These are

some of the questions with which research in rural sociology is concerned.

Research during the past year has dealt with the composition of the rural population and the changes taking place in this population, including migration. Sociologists have explored existing and developing problems in specific localities, areas, and regions, and the need for additional rural and organization activities to help rural people find greater human contentment and satisfaction of living. Still others have weighed the significance to the welfare of rural residents, of local schools, churches, and libraries. Health and welfare as well as local government have been taken into account in research in rural sociology. Income and expenditures of rural families and factors responsible for changes in living standards have been studied. Labor problems and problems growing out of landlord-tenant relations have been analyzed, and studies of social change, involving cultural patterns, urban-rural relationships, social psychology, attitudes, and the adoption of new practices, have been undertaken.

Migration of rural population

The Storrs station (Connecticut) has under way a study of rural population growth and changes. The historical sources and destinations of Connecticut migrants were determined, as were the sources and characteristics and the destinations within Connecticut of more recent migrants, and also some of the socioeconomic differences between such migrants and the 1940 population of Connecticut. Some of the findings were used in preparing the report of the Governor's Committee on Community Adjustment in locating a site for a steel mill in eastern Connecticut. Population data have been tabulated and supplied to the Connecticut Agricultural Extension Service and other study groups of the University.

Intrastate movements of population in Missouri from 1935 to 1940 by 10 economic areas were revealed in special U. S. Census tabulations analyzed by the Missouri station. Interarea migrants had more than average schooling, and many moved into an adjacent economic area. The average educational level of specific areas was raised by the net interchange of population, whereas that of certain other areas was lowered. St. Louis and Kansas City had net losses of population, but adjacent economic areas had net gains. Migrant farmers had more schooling than nonmigrant farmers. Of all farm persons aged 25 or over, 7.6 percent moved between 1935 and 1940; half of them moved within an economic area, and half from one area to another. Of 23,775 interregional migrants classified as farmers in 1940, 38 percent went to farms in economic areas 1, 2, and 3 in Missouri; but 51 percent of those who were college-trained went to farms in these three areas. Movement of farmers was toward better land rather than toward poorer land.

Fewer country doctors in Minnesota

The number of physicians per population in the rural areas of Minnesota has decreased as compared with urban centers. An experiment station survey showed that the physician-population ratio has steadily declined since 1910. In that year the ratio was 914 persons per physician for Minnesota as a whole, and in 1950 the ratio was 1 physician to 751 persons. In the populous counties of Hennepin,

Ramsey, St. Louis, and Olmsted, 1 physician served each 473 people in 1950; by contrast in the rural counties the proportion was 1 to 1,714. Birth rates for 1949 in the rural and urban counties were not greatly different, being slightly higher in the urban counties.

Use of health services in rural area

Data on use of health resources by 1,966 persons during a 12-month period, in 533 representative rural households in Cortland and Oswego counties, were analyzed by the New York (Cornell) station (coop. USDA and U. S. Public Health Service). An enumerative survey, comparable to that in the first two counties, was also made in two western New York counties, Chautauqua and Livingston, where data were obtained for 1,687 persons in 486 representative rural households. The Cortland-Oswego data show that 94 percent of the households and 72 percent of the individuals consulted physician, hospital, dentist, or other "health" personnel during a 12-month period. Factors that had a bearing upon the use made of health personnel were: Income, socioeconomic status, occupation-residence, age, and sex.

Rural schools need greater emphasis on skills

Young men who had attended the sixth grade in 1939 in 10 Vermont towns were interviewed regarding educational and work opportunities, living standards, employers' attitudes toward hiring young men, and use of leisure time in their respective communities. These young men felt that rural schools were inadequate, especially since good teachers resented teaching there. Those who continued on to high school said that city teachers looked upon them as "not too bright" after finding that they came from rural areas. The problem of transportation kept many from continuing to high school. The young men felt a lack of confidence in competing with students from village schools. Their employers felt that teachers should have placed more emphasis on the dignity of work rather than upon the prestige associated with some occupations.

Despite these early handicaps, however, few of the young men are today engaged in dead-end occupations. Lack of education did not keep many from entering skilled trades or acquiring a business of their own. A comparison of their present living conditions with the homes from which they came shows that about 80 percent of the young men have raised their living standards over those of their parents.

Advantages of community-type 4-H Club organization

The West Virginia station compared 4-H Clubs organized at schools with the nonschool, community-type of 4-H Clubs. The following differences stood out: (1) School clubs tend to have more members on the average than community clubs and are more frequently supervised by male teacher-leaders; and (2) community clubs are more apt to have volunteer year-round leadership, more meetings per year, more public meetings, more community projects, active adult councils, higher re-enrollment rates, higher camp attendance, members of greater average age, greater length of membership, greater stability, and more projects per completing member. Club effectiveness—in terms of completion, re-enrollment, length of membership, club longevity, and club mortality—was shown to be closely related to the integration of the club organization with the social area in which it functions.

Retirement and rural housing problems

A study of 200 old-age and retirement records of pensioners, conducted by the Colorado station in cooperation with Larimer County and Colorado welfare departments, shows that farmers do not have more economic security than nonfarmers. They seldom retire until forced to do so by physical incapacity. The analysis of farmer retirement is being used by welfare authorities in recommendations for revision of pension laws and by the Extension Service in educational programs. Another study by the Colorado station shows that Mexican migrant labor in Colorado has an important bearing on the problems of housing, sanitation, health, and child welfare. Mechanization is not solving the general labor problem. Cooperative action by communities, the State, and national agencies will be required to overcome the problems of family labor and to meet the need for adequate incomes for this group of workers.

Personality pattern of children related to environment

The Nebraska station tried various personality measurements on 74 high school students in Syracuse, Nebr., over a 2-year period. Correlation of individual social acceptance ratings were found to have a value of 0.91, indicating that such acceptance ratings have a strong tendency to persist for at least 1 year, and also that such tests are reasonably reliable despite the flux in high school populations. The social acceptance ratings of farm students who attended rural district schools were on the average considerably lower than the ratings of farm or town students who attended grade school in town.

Source of child-rearing information

The Ohio station undertook a family life study in Miami County to establish what the most common child-rearing practices were and what sources and types of child-care information 11 parents of preschool children used. The sources the parents used most frequently and considered most reliable were: (1) The advice of relatives; (2) printed materials such as books, bulletins, and magazines; and (3) the mother's own method and past experience. Help from professional individuals and from lay groups was used less often. No single factor, like age or education of parents, socioeconomic status, or specific resources, seemed to be mainly influential in determining child-rearing practices.

Public relations activities of county agents

The Michigan station made a statistical analysis of certain data in the annual reports of county agricultural agents. A distinction was made between two groups classified as "successful" and "less successful". Those in the successful classification reported more use of radio and newspapers than the others. Also, agents in the successful grouping spent more days outside the office talking with farmers or visiting farms in the county. Through the use of such modern communication facilities, as radio and television, county agents can reach a much wider circle of the citizens they are expected to serve.

Rural health survey in Indiana

A field survey of the health and medical care practices of rural families in three Indiana counties has been launched by the State

experiment station. The survey data secured by trained interviewers and, in all, 603 schedules were completed. In selecting counties as sites for the study, attempt was made to find areas that would reflect the following status of health and health services: (1) One county above average, (2) one county below average, and (3) one county about average. The study was planned in consultation with the State Board of Health, which also provided assistance in the field interviews. Although the results of this research are not yet forthcoming, it is cited to indicate the careful planning and cooperation necessary in conducting research to meet specific ends.

Actuarial study on aging in Louisiana

Efforts are under way at the Louisiana station to ascertain the extent of the aging process among rural residents in the State, and to construct life-expectancy tables for the State's population by sex, race, and residence. The number of aged persons, 65 years and over, more than doubled proportionally among rural Louisianans between 1910 and 1950. The tables disclosed that rural people in the State live longer than urban people. As an illustration, the life expectancy of rural white males under 1 year of age in 1940 was 64.96 years as compared with 57.64 for urban white males. The differential favoring rural people prevails among both white and Negro populations.

Basic trends of social change in South Dakota

In conducting a study of the basic trends of social change in South Dakota, special emphasis was placed on farm families in the Belle Fourche irrigation district. Some of the social changes taking place in the district may be accounted for by rapid adjustments in agriculture over the Nation, whereas others are the result of social adjustments in the area itself. Changes observed include population adjustments to irrigation practices, the shift from farm horsepower to mechanized farming, increases in the size of farms, inventions, and availability of modern farm homes.

Rural people's attitude toward secondary education

Factors influencing the attitudes of Wisconsin rural youth toward farming, rural life, and education were studied by the Wisconsin station. There was a wide range in the attitudes of farm parents to high school education for their children. Factors associated with these attitudes were nationality background, religious background, economic status, educational level of parents, age of parents, and work demands on the farm. Those of high economic status were most favorable to high school education. Younger parents and parents with high educational attainment were most favorable toward secondary education. Those with high socioeconomic status expressed more favorable attitudes than those with low status. Dairy farmers were less favorable in their attitudes toward high school education than were nondairy farmers.

Farmers' opinions of cooperatives

A study of farmers' cooperatives by the Iowa station has dealt mainly with two things: (1) The opinions and actions of the farmers of Iowa toward cooperative principles, practices, and policies, and (2) the exploration of the relationships between cooperatives and the communities in which they were located.

Most Iowa farmers joined cooperatives mainly to save money and stated that economic savings had been the greatest benefit they had received from their cooperatives. Most farm members supported the generally accepted principles of returning savings to patrons on the basis of patronage, limited interest on capital invested, and voting on the basis of one vote per member. Two-thirds agreed with the practice of selling at prevailing prices. Half of the members subscribed to complete open membership in cooperatives and the practice of operating on a cash basis. Seventy percent of the members felt they had some responsibility to their cooperatives. However, the majority of the members did not look upon 100 percent patronage as one of those responsibilities. In fact, more than half thought that members were justified in not trading with the cooperative under some conditions, and in practice two-fifths of the members did split their business with competitors of their cooperative.

General satisfaction was expressed among cooperative members concerning the savings made for them by their cooperative, and the efficiency of their cooperative and its managers. Ninety-seven percent of the members felt that the prices at the cooperatives were as good as or better than competitors' prices. Eighty percent felt that the cooperatives were effective in bringing about a more competitive market. A third of the members voiced criticisms of their local cooperatives.

Sixty percent of the members thought that cooperatives made profits and 35 percent thought cooperatives should pay income taxes. More than half of the members stated that cooperatives should not pay income taxes. Members thought the responsibility of financing cooperatives should rest largely with local members.

AGRICULTURAL ENGINEERING

Farm mechanization is generally recognized as the major contributor to United States farm efficiency. Behind the development of each agricultural machine there stands a vast amount of scientific research. The specialists at the State experiment stations who are concerned with developments in this field are primarily the agricultural engineers. Their problems range from ordinary farm activities to such exacting jobs as developing new devices to permit the conduct of complicated research in various farm-engineering fields.

Eighty-five percent of agricultural research has engineering phases or implications. Often the research is set up by commodities—cotton, corn, hogs, cattle, or other crops or animals. However, engineering phases are included in all these fields many of which deal with production, storage, housing, processing, and marketing.

Many agricultural machines and devices are still in the experimental stage, but in all probability, some of them will become realities because farmers, agricultural engineers, and implement manufacturers realize that they are needed.

Although the most striking gains have been made by machines used for tilling and harvesting field crops, machines are needed to make comparable savings in growing fruit and vegetable crops. Better crop conditioning and storage facilities are especially needed. More research must be done in this field, particularly during the present period of defense mobilization.

From the operating farmers themselves come many suggestions for improvement in agricultural production methods. Progressive farmers are asking their experiment stations continually for the answers to practical problems. A few typical examples of progress results recently announced in this field follow.

New mechanisms developed for harvesting pecans

The Texas station reports development of two experimental labor-saving machines for hulling and separating pecans. This crop is an important one for the State—about 36 million pounds were produced in 1949. Mechanical tree shakers operated by tractor power have been developed recently which save some of the labor involved in hand harvesting. Hand labor has been further reduced by spreading tarpaulins or sheets under the trees from which the nuts may be more easily collected.

New husker and separator machines have been developed which enable workers to harvest much greater quantities of pecans in less time than is possible by hand labor. The separating mechanism consists of two vibrating trays with screen bottoms, one located immediately above the other. The coarse upper screen has 1½-inch openings which permit the pecans and husks to fall through onto the second screen, but retains and discharges the leaves and twigs. The lower screen, made of $\frac{3}{16}$ -inch steel rods spaced $\frac{5}{8}$ inch apart, permits the husks to fall through but retains the pecans, which are gradually discharged at the lower end. Cleaned pecans are separated from those with attached husks through openings near the discharge end of the lower screen and the unhulled pecans flow out over the end of the screen.

The pecan huller, consisting of two vertical series of adjustable horizontal $\frac{3}{16}$ -inch steel rods spaced about 1 inch apart, removes the husks from the pecans that have not separated naturally. The pecans are fed between the opposite moving series of rods by gravity. The huller is mounted on the end of the separator and both units are operated by the same mechanism that provides vibration of the horizontal screens.

Records of performance with this new equipment showed that a tree yielding 100 pounds was harvested and bagged in 30 to 40 minutes. It is conservatively estimated that two men can shake down, clean, and bag over 800 pounds of pecans in an 8-hour day.

Hay drying fans given increased efficiency

The Massachusetts station has obtained more basic information on the water-evaporating capacities of fans used in hay drying in detailed tests conducted in the recently installed plenum blast tunnel. Tunnel testing of standard, commercially available, two-blade fans of 42-, 54-, and 72-inch diameters run on 3, 5, and 7 horsepower has shown that the manner of fit of the fan blade to the mounting ring may change the air delivery as much as 10 percent with the same horsepower requirement.

New hay-drying installations based on these results have given about 50 percent increase in evaporating capacity for 5-horsepower motors. Savings to farmers are estimated at \$300 to \$400 per unit in terms of water-evaporating capacity and of at least 30 percent in energy.

New design for grass-terrace and overfall structures

Hydrologic studies conducted at the Missouri station have disclosed inaccuracies in design data for grass-terrace and overfall structures, indicating that the amount of runoff to be expected from watersheds is sufficiently less that the sizes of grass outlets recommended can be reduced by 10 percent. A new design has been developed for overfall structures, to be placed at the end of terrace outlets, which have increased discharge capacity and made possible a savings of about \$20 per structure. At present, 9,000 structures are needed in Missouri to protect existing terrace outlets. Use of the new designs in outlets and structures will permit a saving of some 2 million dollars.

Inexpensive soil erosion controller

The Hawaii station developed a simple and inexpensive erosion control device to reduce the velocity of discharge from gated irrigation water before it enters the furrow.

The device is constructed of 24-gage galvanized sheet metal shaped to baffle the jet. Its dimensions are 3'' \times 3'' \times 12''. Excellent results have been obtained with discharge rates of 15 to 20 gallons per minute under 35 to 40 feet of head. Rates of application up to 45 gallons per minute may be used under low heads. The maximum rate of application of water for most crops in Hawaii is about 17.5 gallons per minute per 200 feet of furrow. The range in which the devised controller is effective varies from 5 to 45 feet of head and 12 to 46 gallons per minute.

In tests of the erosion controller with water flowing at a rate of 0.02 cubic foot per second at a head of 10 feet after 4 hours of continuous operation, only 15 cubic inches of soil were moved as contrasted with 4,000 cubic inches of soil moved by an uncontrolled discharge.

Mining mechanism simplifies grain handling

Feed and grain handling is one of the laborious tasks on the farm. The West Virginia station has been attempting to adapt a low air pressure mechanism for conveying grain to feeding areas on the farm, developed by the United States Bureau of Mines for transporting powdered coal.

The tests showed that slightly more than 1 ton of wheat could be moved in 1 hour through 75 feet of 1-inch pipe arranged horizontally and vertically with three right-angle turns of 4-inch radius and one U-turn with a 1-foot radius. The quantity of air required was 14 cubic feet per minute, at 5 pounds per square inch pressure. The power requirement was roughly 1 horsepower per ton of grain moved. The principle appears to be adaptable to the farm. The advantages are that small-sized, easily placed and moved pipe can be used, feed stuff can be transported around bends and for relatively long, horizontal and vertical distances within a building or from one building to another, and the initial cost and maintenance should not be excessive.

Prefabricated corn crib made of native Illinois lumber

An inexpensive prefabricated crib approximately 12 feet in diameter and 12 feet high has been developed and built at the Illinois station (coop. USDA) using native hardwood lumber in the grades and sizes commonly produced by local sawmills. The crib consists

of a floor with a sheller drag chute, 12 wall sections, a ventilating flue, and a tarpaulin as a roof. It is erected by standing the wall sections into place on the circumference of a circle and bolting the wire loops of adjacent wall sections together with 1" \times $\frac{1}{4}$ " machine bolts and washers. The new crib has given excellent performance. The design permits farmers to save cash through the use of materials grown in local wood lots. Small sawmill operators may manufacture a packaged unit of precut materials or a prefabricated form to be assembled by the purchaser.

Lowering sugar loss in piled sugar beets

Storing sugar beets has been a difficult process. Even after beets are pulled and topped respiration continues, resulting in heating and loss of sugar which, in the eastern sugar area alone, amounts to nearly 11½ million dollars annually. The Michigan station reports studies indicating that sugar losses were reduced by directing a flow of air through piles of beets by means of fixed ducts. Ventilation of the piles reduced sugar losses to one-third to two-thirds pound per ton per day—a saving of 75 to 80 percent of the usual losses in unventilated piles. The greatest saving was made with air of 80-percent humidity blown at 20 cubic feet per minute per ton. However, blowing ordinary night air through the ducts beneath beet piles gave the most effective, simple, and practical treatment.

Cannery wastes turned into fuel gas

One of America's big problems is the disposal of thousands of tons of peelings, cores, and other waste material obtained annually in processing such foods as fruits and vegetables. Dumping such refuse into streams causes serious river pollution. Piling it up on waste land is unsanitary. The Oregon station evolved a promising method, now in the pilot-plant stage, for the disposal of waste from pear canning. Using forms of bacteria which thrive on carbohydrate material like pear waste at a temperature as high as 130° F., and in the absence of oxygen, a means has been devised for the continuous production of burnable methane gas. By this method 12 cubic feet of the gas may be produced for every 6 pounds of fresh pear waste put through the pilot plant. Active fermentation was maintained successfully over a total continuous period of 9 months. The gas produced at the indicated rate with 90 tons of waste from 250 tons of pears delivered to a cannery in 1 day would, at city rates, be worth about \$225.

Machines developed to aid corn millers

To make enrichment of corn practical for millers, a special feeder machine was developed by the South Carolina station. This makes possible the addition of niacin, riboflavin, thiamine, iron, and calcium to corn meal and corn grits. The research influenced the passage of legislation requiring the enrichment in this way of all South Carolina corn products. This type of machine is now being utilized not only by South Carolina millers but also in other Southern States.

Better cultural practices for growing cotton

The Arkansas station is carrying on research aimed at improving cultural practices for growing cotton. The planting practice of hill-dropping to a stand continues to show promise. Using delinted seed of 80 percent germination, a test planting of 4 to 6 seeds per hill on 8-inch centers in the row was successfully accomplished at ground

speeds of $2\frac{1}{2}$ to 3 miles per hour. Speed in excess of this amount strung out the seed to the point where the effects of hill-dropping were lost. By this method 50 percent of the seed required per acre was saved or approximately 20 pounds per acre. Two million acres of cotton are planted in Arkansas alone. If this practice were used on the entire acreage, savings in amounts of seed cotton needed would be nearly 20,000 tons or about 5 million dollars annually.

The Arkansas station is also developing a new method of applying dry fertilizer at planting time. Application is accomplished by the use of a disk opener placed just ahead of the planting mechanism. This method saves two field operations—fertilizer application and re-bedding the land before planting. If the principle were applied to the cotton acreage of the State, savings of at least two-thirds man-hours plus two-thirds tractor-hours per acre would result, or 1,333,333 man- and tractor-hours valued at approximately $2\frac{1}{2}$ million dollars.

Apple dumper speeds work and cuts labor

A simple, inexpensive mechanical aid that makes it possible for workers to dump fruit onto grading and packing lines with less effort has been devised and tested at the Michigan station (coop. USDA).

The machine consists of a pivoted crate holder supported by a rigid frame in such a way that filled crates can be quickly and easily raised and dumped. Leverage and a strong spring aid the operator. During the dumping operation, the flow of fruit is regulated so that bruising is materially reduced. Developers of the device say the machine should be of value in handling any fruit or vegetable crop that is poured from field crates to packing lines.

The dumper was tested in commercial packing houses during the 1950 season and attained a capacity of several hundred bushels an hour. Use of the dumper made it easy for the operator to control the flow of fruit, so there is an almost continuous supply to the packing line. Ordinarily the dumper's job is a difficult one, but when the aid was installed, the work could be performed by women.

New drier affords safer farm storage of nuts

The Oregon station reports the development of a 500-pound (dry weight) nut drier for walnuts or filberts using electricity as the source of heat. Construction costs of the complete unit was about \$125 for materials and $76\frac{1}{2}$ hours of labor.

In operation, a load of 660 pounds (wet weight) of filberts was dried to 493 pounds in 35 hours (25 percent moisture loss by weight) with a current consumption of 163 kilowatt-hours—0.33 kilowatt-hours per pound of nuts. At a power cost of 2 cents per kilowatt-hour, the nuts were dried to a safe moisture content for two-thirds cent per pound. This cost compares favorably with that paid for other types of heat or fuel. The unit makes equipment available at a reasonable price which will enable the farmer to condition his product on the farm for safe keeping. He may then market his crops when prices are most advantageous.

Tobacco production further mechanized

Continuing its efforts to mechanize tobacco production the Maryland station has developed an experimental machine which will suc-

cessfully perform the time-consuming operation of stick spearing. During a test run of 1,000 sticks, 2 men using the new machine speared three complete sticks of tobacco per minute.

Liquid-petroleum gas for tobacco curing

The Connecticut Agricultural Experiment Station and the Storrs station (Connecticut) (coop. USDA) compared liquid petroleum (L-P) gas with conventional charcoal briquets as a source of fuel for curing shade tobacco. L-P gas firing produced tobacco which graded out with an average value of 45 cents per pound more than tobacco cured by the charcoal method. Furthermore, fuel costs were reduced as much as \$50 per acre in the gas-fired sheds. Combined benefits add up to an increased income of approximately \$500 per acre in favor of the L-P gas fuel. The cost of installing the gas system, which includes piping, gas burners, valves, flexible hoses, and labor, using March 1, 1951 prices, would be from \$1,000 to \$1,200 for a 5-acre shed.

Economical new conveyor saves steps

The New Hampshire station reports the development of a gravity conveyor for moving baled hay. Analysis of results obtained by using a 10-foot conveyor in moving 100 bales of hay 10 feet disclosed that 2,000 feet of travel is saved. On certain farms this new equipment can be set up so as to save one or more trips to the mow each day at a cost for materials of around \$25.

Extra heat aids drying of hay

Hay-drying experiments at the Alabama station disclose that supplemental heat reduces drying time by one-fourth, thus increasing the capacity of a hay-drying installation fourfold. The use of heat increases the drying cost approximately 12 percent, but this increase is justified because of the elimination of risks due to unfavorable drying conditions.

New type sewage system for farm homes

The problem of installing sewage systems for farm homes in areas of tight soils and high water tables has been solved according to the North Dakota station. A new-type sewage system with a surface-type disposal field has given extremely satisfactory results for 2 years. Its installation costs no more than the typical system now in common use for the area, which calls for a sump in the basement. Operating cost obtained for the new system installed at the station was 3 to 5 cents per month and the cost of maintaining a disposal field was eliminated.

ANIMAL PRODUCTION

Considerable national attention is focused on meat as a result of the mobilization program; and livestock production, always one of the chief agricultural enterprises of the Nation, has responded. Full employment in industrial plants, increasing manpower needs in the military establishments, and a growing population, are factors that stimulate demand for meat and meat products. Fortunately, to meet these increased needs, there were 8,754,680 more meat animals on farms and ranches on January 1, 1951, than on the same date in

1950. The experiment stations are putting particular emphasis on research that will help livestock men maintain and increase this production through improved methods of breeding, nutrition, and management.

Better Nutrition for Increased Efficient Gains

Swine

Until recently it was believed that simple-stomached animals, such as the pig, could not utilize elemental cobalt. The North Dakota station has shown that this is a misconception. Pigs fed rations to which either cobalt or a trace mineral salt was added showed increased gains of 12 percent or 0.2 pound per day. The cost of the cobalt to produce this gain was about 5 cents. Gains were increased still further when meat scraps were added to the ration. These gains were made with a substantial saving in feed utilized per pound of gain.

Of the 40 percent of pigs born which never reach market, many die during the suckling period or soon after weaning. The Arkansas station reports that when baby pigs are fed on purified diets, those given starch or sucrose as a source of carbohydrates synthesize appreciably more vitamin B₁₂ than those fed glucose. Research at other stations and in the Department has already shown B₁₂ to be the important factor in animal protein supplements and in several fermentation byproducts obtained in the manufacture of antibiotics.

The Arkansas, Texas, and South Carolina stations (coop. USDA) fed a new-process cottonseed oil meal which is low in gossypol to weanling pigs. Excellent growth was obtained especially when the meal was supplemented with the amino acid lysine.

Other vitamins are important to enable young pigs to reach the consumer and save expensive feed. The Missouri station discovered that the addition of riboflavin, pantothenic acid, and nicotinic acid to a typical corn-soybean oil meal ration stimulated the rate of growth of young pigs. No additional response was obtained when a vitamin B₁₂ concentrate was added to these vitamins. The antibiotics, aureomycin and penicillin, stimulated growth of weanling pigs on an all-vegetable diet, whereas chloromycetin gave no response.

Cattle

A wider knowledge of grassland farming and improved ways of handling crops has spread to all parts of the United States, resulting in increased liveweight gains per acre at reduced cost, and more efficient use of forage production.

For example, studies by the Alaska station show that storing brome-grass in the form of silage is the most practical and economical method for feed preservation in Alaska. A pound of dry matter in silage was 33 percent more efficient than a pound of dry matter in field-cured hay. Dry matter losses from cutting to storing were 41 percent for field-cured hay and only 21 percent for silage. The average cost of processing field-cured brome-grass hay was \$28.43 per ton of dry matter, whereas silage cost only \$18.05 per ton of dry matter to process. This research has resulted in the construction of a large number of silos in Alaska during the past 3 years.

New feeds, particularly byproduct wastes, are constantly being studied. Their use frequently makes more cereals available for human consumption.

Results of two tests at the Arizona station with dried waste cantaloup show that this product may be used profitably as a cattle fattening feed. It fully replaced one-half of the barley allowance in a ration of alfalfa, hegari silage, and cottonseed meal.

The sugar industries of Hawaii, Louisiana, and Florida have a large volume of a waste material, bagasse, the residue from the cane after the juice is pressed out. Studies at the Hawaii station show that bagasse, when treated with sodium hydroxide to increase its digestibility, becomes a satisfactory cattle feed. Tests showed that 11 pounds of treated bagasse (dry basis) replaced 41 pounds of green Napier grass. The treated bagasse proved definitely superior to the untreated material used in a steer-feeding trial. These findings point to new procedures in making animal feeds from sugarcane byproducts.

Through the application of research, Florida has improved the quantity and quality of its cattle in the past 5 years. In 1944-45 it was estimated that there were 2,000 cattle in the Everglades area in Palm Beach County. In 1950-51 as a result of the knowledge gained of trace element nutrition, it is conservatively estimated that there were 20,000 to 25,000 cattle in the county and that the cattle are far heavier and better than formerly. In 1944-45 the weaning weight of calves in the range cattle area was usually 175 to 200 pounds at 7 months or 250 to 300 pounds at 1 year; the calf crop was less than 50 percent. In 1950-51 following use of information developed in research the calf crop has increased to between 60 and 70 percent or more in many herds and weaning weights at 6 to 7 months average from 350 to 450 pounds. This program was brought about in part by larger cow sizes and better lactation performance resulting from improved nutrition practices.

The South Dakota station fed soft ear corn containing up to 40-percent moisture to yearling steers, which made better gains than similar steers fed hard ear corn during the winter of 1950-51. The soft corn was highly palatable and the steers reached maximum consumption early in the feeding period. The results demonstrate clearly that soft corn has a feeding value for fattening steers equal to hard corn on a dry-matter basis. It should be fed before warm spring weather sets in, as high temperature favors spoilage.

Sheep

Ruminants are particularly valuable as converters of low-grade feeding stuffs into desirable animal products for human consumption.

Poor alfalfa hay fed in cubes to lambs by the New Mexico station yielded practically as much profit as when good hay was fed by hand. Less skill was needed and labor costs were reduced 80 percent by use of the self-feeding cubes. Self-fed lambs gained 26 percent faster and required 30 percent less hay and 7 percent less grain than the hand-fed lots.

Safflower meal is a satisfactory protein supplement which can replace part of the grain in a lamb-fattening ration, if it costs less than grain, according to the Wyoming station. It replaced soybean meal pound for pound in a ration of barley plus beet pulp and alfalfa hay. Satisfactory gains were made when one-fourth of the concentrate was composed of 18 percent safflower meal. Self-fed lots made better gains, although the cost per 100 pounds of gain was higher than in the hand-fed lots.

Studies on the protein requirements of lambs at the New York (Cornell) station point to need for a higher protein supplement than is ordinarily fed to light-weight lambs. It was found desirable to initiate feeding with 12- to 13-percent total protein in the fattening ration and to reduce the intake to 10 to 11 percent during the last part of the feeding period. Adoption of this practice would result in more efficient use of the \$1,000,000 worth of supplement fed to lambs in New York State alone, since some feeders use too much and others not enough.

Improvement Through Breeding

Until recently, breeds and strains of livestock in the United States have been maintained practically as they were received from overseas. As in plant breeding, however, geneticists have been able to prove that the flow of germ plasm can be scientifically directed to improve our existing animal stocks and to perfect better ones through various crossings. The problem is difficult because of the time needed and because in any one mating there is usually but one offspring. However, effects of scientific animal breeding are beginning to make practical contributions to more efficient livestock production.

Swine

An integrated program of swine breeding research carried on cooperatively by the United States Department of Agriculture and numerous experiment stations has been under way for some years. The purpose has been to develop lean-meat-type hogs. Foundation lines have been developed at Beltsville, Md., and other lines have now been established at 14 experiment stations which are cooperating with the Department's Regional Swine Breeding Laboratory at Ames, Iowa.

From an original cross of Chester White sows mated to USDA Danish Landrace boars, the Washington station developed a bacon-type hog suitable to the feed and climatic conditions of the State. Some of the hogs in this line are now in the F_6 generation. The fertility and survival of this strain has shown improvement since the F_2 generation and these hogs are proving to be very popular under farm conditions. Several breeders propose to deliver kill lots to private packers in return for a premium price on hogs of this strain, as the packers are well pleased with the killing qualities. Analysis of a 3-year carcass study and comparison of "No. 61" hogs with pure-bred Chester Whites showed that on an average the No. 61's were 1.38 to 2.24 inches longer in body, and had one-half inch less back fat, a heavier and longer loin of more area, a heavier, higher quality belly, a greater area of lean in ham cross section, and a higher percentage of protein. Although lard-type hogs have had a higher dressing percentage than the No. 61's, the latter have produced a carcass with a higher percentage of primal cuts and about 25 percent less lard.

Cross-breeding of swine in which a good black native hog, Durocs, and Landrace were used in different combinations to produce an improved pig, has resulted in 50 percent fewer still-born pigs, around 33 percent more pigs weaned per litter, about 63 pounds more per litter at weaning, and a faster rate of gain, as a result of research at the

Puerto Rico station. Pigs having good weaning weights may be expected to make maximum gains when fattening. This increase in meat production is of great importance to the economy of the Island in times when ship space may be at a premium.

Over a 7-year period, outbred Duroc and line-cross Duroc litters average 7.8 and 7.9 pigs and 1,420 and 1,579 pounds in weight at 180 days of age and required 377 and 374 pounds of feed per 100 pounds of gain, respectively, at the Ohio station. The 1950 outbred Duroc, line-cross Duroc, and breed-cross litters averaged 7.0, 8.3, and 9.1 pigs and 1,288, 1,499, and 1,660 pounds in weight at 150 days of age. The data indicate that commercial hog producers can secure heavier litters at a given age by producing line-cross or breed-cross than by producing grade or purebred pigs, practices which are already being adopted by Ohio hog producers as a result of this research.

The Oklahoma station (coop. USDA) by crossing Duroc lines with other breeds has produced carcasses having a wholesale value of about \$1 more per 100 pounds of live hog (at March 1951 prices). Carcass improvement was obtained without any sacrifice in rate of efficiency of gain. Some line-crosses are now being tested under farm conditions, and breeders are testing other line combinations in a search for still more efficient production.

The Missouri station undertook a comprehensive series of experiments (coop. USDA) on the nature of inbreeding and cross-breeding effects on the performance of swine. The research showed that heterosis produced numerous advantages under full feeding—increase in growth, greater and more economic postweaning gain, greater muscle and bone development instead of fat, and greater fertility of gilts. Such heterosity was much stronger when crosses were made between breeds than in linecrossings within breeds.

Swine breeding research at the South Dakota station (coop. USDA) has shown that a rotational cross of inbred lines from four breeds offers real promise as an efficient mating system to be used by producers primarily interested in raising slaughter hogs. This cross, in comparisons including an outbred check or control, excels in fertility, livability, weight for age, and economy of feed usage. The sows are excellent mothers and have a narrow ratio of services per conception. Some system of rotational breed crossing, rather than the common practice of outbreeding, appears especially valuable for slaughter hog production.

Cattle

Since 1946 the Department, in cooperation with 39 State experiment stations and Hawaii, has engaged in a concerted beef cattle improvement program that has the full-hearted support of stockmen and breed associations.

In Montana, as a result of State experiment research (coop. USDA), commercial cattlemen are seeking bulls that have been selected and tested for rapid and efficient gains. Feeder buyers are paying premiums of \$2.75 to \$3 per hundredweight for steers from herds using such bulls, with a difference of \$30 to \$40 in net return per steer above feed cost of one sire group over another. If only one-fourth as much difference in net return could be had for Montana's entire beef output, it would mean a net increase of 4 million dollars annually.

Typical of results obtained individually in a cooperative venture by the Kansas, Oklahoma, and Ohio stations, is the report from the Kansas station that medium-size Hereford cattle tend to return more to the producer than extremely small or large-size cattle. In Kansas medium-size steers sold for 25 cents a hundredweight more than small steers and for 91 cents a hundredweight more than large steers. This research was supported in part by the American Hereford Association and was an attempt to answer a practical question often raised by feeders and breeders "What size cattle should be raised?"

Considerable publicity has recently been given to so-called "midget" or "dwarf" cattle. South Dakota station findings show that this character is inherited. The California station is applying that finding for the benefit of the cattle breeder by measuring heads and taking other anatomical and endocrine measurements. Heads of heterozygotic animals, the ones that carry and are able to transmit the dwarf gene to offspring, apparently differ in certain aspects from normal noncarriers. Owners of animals in herds throughout California and in some other western States are cooperating in an effort to rule out the disastrous dwarf character in their breeding programs.

Cancer eye, a serious ailment causing the loss of many range cattle, has been studied by the Oregon and New Mexico stations. Animals having some pigmentation around the eye seem to be protected. Definite evidences of inheritance have shown that the presence or absence of the eye pigmentation factor is an important heritable character.

That the use of cattle from lines of known genetic origin will pay off to the cattle feeder was shown by the Ohio station which obtained yearling steers from the Department's Miles City, Montana, station to study feed lot performance of these animals in comparison with animals of an apparently equal quality purchased on the open market. The steers of known genetic lines were 9 percent more efficient in feed use and rate of gain. As a result of this work Corn Belt feeders are presently offering premium payments for such animals.

The South Carolina station points out that through controlled cross-breeding 11 percent more weight in weaned fat calves can be obtained. Calves out of Angus cows, sired by Hereford bulls, were lighter than the Brahman crossbreds at birth but heavier at weaning. The carcass grades and dressing percentage were not significantly affected by the breeding of the calves.

Sheep

The Ohio station, interested in revitalizing declining agriculture in the once-prosperous grazing area of southeastern Ohio, has established that lamb production based on "pounds of lamb per ewe at weaning" was raised from a 36-pound average produced by straight Merinos to a 72-pound average produced by crossbred Columbia and Merino ewes bred to Suffolk rams. The lambs attain this weight at weaning on pasture. The wools produced under this system fall into the grades most needed for civilian and military clothing. The result is a self sustained sheep industry for the region.

For 4 years the Virginia station has been comparing the performance of selected native ewes and northwest crossbred ewes with the performance of straight-run commercial native ewes. The experiment shows that the first two types have produced more lambs and

that the lambs have made higher daily gains than the straight-run native ewes. The lambs produced by the first two types slaughtered at "low choice" and "high good." Based on its studies, the Virginia station estimates that the replacement of the 30,000 to 40,000 commercial native ewes which are added to Virginia flocks each year with selected natives or northwest Black Face, would add approximately \$200,000 to the annual income from sheep in Virginia.

The Montana station proved that the average weaning weight of the lambs from one individual ram is often from 1 pound to several pounds heavier than the average weight of other progeny groups under similar environment. If breeders can identify rams which would increase the average weight of their offspring by 2 pounds, a gain of 100 pounds for 50 lambs would result. At 30 cents a pound a single progeny-tested ram would return \$30 more to the producer than an untested ram. The exploratory results found from crossing lines of known productive ability indicate that this is a promising method of breeding for increased commercial production.

Management, an Important Factor

Animals may be bred to the highest degree of efficiency and stockmen may have an adequate knowledge of nutrition and feeding; but without good management practices the animals become less productive or are lost. This not only reduces returns but also the supply of animal products so needed in times of stress.

Swine

Many hogs are needlessly lost from overheating in summertime. In research at the Illinois station pigs gained faster in the summer when they had shade under which to cool off. A pole framework covered on top with brush, straw, coarse sweetclover clippings, or other light material will work very well. The posts should clear the ground by at least 5 feet to let air circulate. Market-weight hogs each need 10 to 15 square feet of space under the shade. The station calculated that losing one pig weighing 150 pounds due to heat means a financial loss of around \$31 in the feed the dead pig has eaten. Thus, low-cost shade made of scraps found around the barn easily pays for itself.

Basic studies at the California station (coop. USDA) with a heat controlled room are revealing important practical facts regarding the relation of the hog to its environment. The station reports that pregnant sows usually carry their young to full term even when the air temperature reaches 100° F. Under these conditions the sow's temperature has gone as high as 105.5° F. But above 80° F. hogs start to get uncomfortable and reduce their food intake. Nursing sows lost as much as 43 percent of their weight in 56 days when the air temperature was held at 90° F., and 26 percent when the temperature was 80° F. High humidity increased the distress caused by high temperatures. Hogs weighing 100 pounds were able to lose almost as much heat through their body surface as 300-pound hogs. This explains why young growing pigs can withstand hot weather much more readily than big old sows. In fact, in the experiments just cited (at 90° F.), one litter of nine suckling pigs grew to a weight of 270 pounds in 56 days while the sow was rapidly losing weight.

Cattle

The winter feeding period is usually a critical one for all livestock. Cows must be brought through in good calving condition and steers on economical rations.

A 5-winter experiment at the Mississippi station demonstrated the importance of wintering bred beef cows in good condition. The addition of 1 pound of cottonseed meal to the grass ration increased the calf crop about 22 percent over the 5-year period.

Studies at the Oklahoma station suggest that the productive life of the average beef cow can be extended and that considerable time and money can be saved by calving heifers at 2 years of age rather than at 3 years. However, such early-calved animals must be well grown and nourished. On the other hand, the Illinois station reports that in an experiment extending over five calvings, more total beef was produced from cows bred to calve at 3 years than from cows bred to calve at 2 years.

A steer ration that contains the right proportion of concentrate in relation to roughage pays dividends. Different methods of obtaining the best balance were tested by the Nebraska, Colorado, Idaho, and other stations. The Nebraska station found the best ratio at around 2:1, that is, 2 parts of concentrate to 1 of roughage. Steers fed at this level made the highest rate of gain (2.76 pounds per day) at the lowest total feed intake (766 pounds) per hundredweight of gain.

Sheep

Of great practical importance in increasing the meat supply is the possibility of producing two lamb crops per year. Ordinarily, the breeding behavior of sheep is seasonal and conception does not occur until fall with its shorter days and cool weather. This phenomenon is related to various naturally occurring hormonal reactions. The Illinois and Colorado stations and the Department are studying the problem from different aspects. Out-of-season lambs have already been produced in numbers in Colorado, through injections of gonad-stimulating materials, whereas the Department has shown that the hormonal influence can be brought about by withholding daylight from ewes during the seasons of long daylight hours.

Farm Meat Preservation

Although locker plants are rapidly increasing, farm curing and storing of meat, especially pork, continues in many areas. Losses ranging up to 50 percent of the meat are frequently experienced, caused mainly by high temperatures, insect damage, or faulty brine penetration. The economics of this waste cannot be ignored, first, because it affects the nutrition of the people on the farm, and, second, because of the vast amount of feed used to produce the spoiled meat.

Experiment stations and the Department are alert to these problems. For instance, the South Carolina station has shown that neither the kind of containers nor temperatures below room temperatures affected the quality of stored cooked sausage and that lard was the most desirable covering. However, bacon, stored at 36° F. under cottonseed oil cover proved most superior. Acceptable hams could be obtained through storage in paper and cloth bags at room temperature.

The North Carolina station has shown that such treatment is essential if the hams are to be kept free from insects.

Even under the best conditions getting the preservative salt mixture into curing meats is not always successful. Research by the Maryland station (coop. USDA) indicates that pumping a salt brine mixture into the hams will save farmers much loss and produce a higher quality, quick cured product.

DAIRY PRODUCTION

Dairy scientists are constantly seeking to improve milk production through the feeding of a better quality of roughage and the development of new techniques for artificial breeding. Interest in research that applies genetic principles to dairy breeding is also high, but because of the cost of animals needed for this type of research and the slow rate at which results can be conclusively established, this phase is undertaken on a long-time basis. Research in disease control is also moving forward within the limits of funds and personnel available.

Nutrition of Dairy Animals

The Kansas station carried on research to establish the kind of silage best adapted for dairy cows. Cows eating up to 100 pounds of alfalfa silage per day gave excellent response. The New Hampshire station obtained very good results with ladino-brome silage, fair results with oat silage, and poor results with timothy silage. Both molasses and SO_2 were used as a preservative. South Carolina reports that cows milked satisfactorily on kudzu and on fescue-ladino clover silage. Wyoming obtained high carotene values for sunflower silage and recommends it as a dairy cattle feed.

Cows fed a high quality of roughage by the New Jersey station produced most economically when grain was fed sparingly (1 pound for each 6 pounds of milk produced). With high-quality roughage each pound of grain when fed sparingly produced 0.71 pound of 4-percent milk, whereas when grain was fed at the rate of 1 to 3 pounds of milk produced, each pound of grain accounted for only 0.51 pound of 4-percent milk.

Vermont research has shown that hay allowed to lie in the field only a short time and then artificially dried in the barn contains adequate amounts of vitamin D for growing cattle.

Minor elements

In spite of the fact that sulfur is an important component of certain so-called essential amino acids, the cow requires only a small amount of sulfur in her diet. With three groups of growing heifers (five animals per group) the Oregon station found that the sulfur-supplemented groups made greater gains on the average than did the nonsulfur-supplemented group. Probably the most surprising part of the results was that inorganic sulfur (sodium sulfate) appeared to give just as good results as organic sulfur (in the form of methionine). However, adding 1 percent of sodium sulfate to the grain mix of the milking herd on a low-sulfur ration produced no effect on weight, milk or butterfat production, or feed consumption.

Plants grown on soil high in molybdenum contain sufficient molybdenum to be toxic to dairy animals. The Florida station found that small amounts of copper keep essential phosphorus in the cow's ration from being wasted (excreted) in the presence of excess molybdenum. Rats given a ration containing 80 to 140 parts per million of molybdenum failed to breed. The station emphasizes the advisability of feeding plenty of calcium and phosphorus if molybdenum poisoning is suspected; it warns, however, that commercial mineral additives caused destruction of essential vitamins in the ration. The Massachusetts station analyzed milk for its molybdenum content. The results showed that molybdenum is a natural constituent of cow's milk, averaging 73 micrograms per liter. In the samples tested it varied from 18 to 147 micrograms, depending on the molybdenum content of the feed.

Dairy Cattle Breeding

Show-ring appearance does not necessarily reflect the milking capacity of a cow. The West Virginia station found that professional dairy judges failed to classify the same animal in the same type class about half of the time, largely because she looked different at different stages of lactation. In tests with 189 sires this station established that breeding sires classified good as to type to similarly classified cows usually result in good type offspring, although generally they are not as good as the sires if the latter were far above average. Poor type sires usually produced poor type calves, although not always as poor as the sire if the latter were poorer than the average.

The genetic correlation between milk and fat production was 0.71 at the Iowa station. This means that in selecting for high milk production one automatically selects for high fat production (not percent fat), or vice versa. The data offer no evidence that type and production are closely related.

The Texas station (coop. USDA) found no correlation between the number of sweat glands of Brahman and Jersey cattle and heat tolerance but it did find a relationship between the density of hair coat and rate of respiration in these two breeds. Contrary to what one might expect, the Brahman hide had an average of 1,775 hairs per square inch and the Jersey hide, 1,095 hairs. The average hair length of the Brahman was shorter than that of the Jersey. The preliminary findings indicate that hair density may in some way be related to heat tolerance.

In trying to improve cattle through breeding, the Iowa station obtained little evidence that cows inherit any appreciable resistance to mastitis.

Research in Breeding Methods

Again this year there has been timely research dealing with improved techniques in artificial breeding associations. In spite of these new techniques for maintaining the viability of semen, the New York (Cornell) station found that 4 percent more cows settle on first service if inseminated with 24- to 36-hour-old semen rather than 48- to 60-hour-old semen. The Arkansas station secured additional proof

that semen must be kept cool if it is to retain its viability for any appreciable length of time. Semen kept at 38° F. retained its ability to fertilize up to 196.5 hours, but semen kept at room temperature lasted only 43 hours.

The administration of the male sex hormone, testosterone, to normal bulls had no effect on their breeding efficiency according to the Colorado station.

For years dairy scientists have been trying to transplant the fertilized ovum from one cow into the reproductive tract of another cow. At last this has been accomplished by the Wisconsin station (coop. USDA). The final aim, of course, is to use inferior cows from the standpoint of milk production as the foster mothers (incubators) for the developing embryos of high-producing cows.

Care of Calves

By raising calves on a synthetic diet, the Illinois station has been able to determine which vitamins are necessary for normal growth before the rumen has begun to exercise its usual function of breaking down roughages, synthesizing new vitamins and proteins (through action of microflora), and as a food reservoir. By knowing exactly which vitamins are necessary, wasteful methods of feeding vitamins can be avoided.

Vitamin B₁₂, the animal protein factor which is so important in baby pig nutrition, is of little value in calf feeding according to reports from Maryland, Ohio, New Jersey, and Pennsylvania. But calves do much better when raised on milk substitutes if a small amount of aureomycin is added to the feed. Calves at New York (Cornell) fed the antibiotic consumed approximately 40 percent more concentrates than the controls and they required less total digestible nutrients to make 1 pound of gain. The incidence of diarrhea was also reduced. Similar results have been reported by the Louisiana, Kansas, and Iowa stations. The Minnesota station learned that streptomycin is not a substitute for aureomycin although calves on streptomycin did not "deteriorate" as rapidly.

Thyroprotein was ineffective in stimulating the growth rate of calves according to the New Jersey station. According to the New York (Cornell) station it does little good to give calves vitamin A and D tablets or even niacin and ascorbic acid, but beneficial effects were obtained by feeding the dam a massive dose (1 million International Units) of vitamin A during the last few weeks before calving. Not only was the calf already fortified with ample reserves of vitamin A when born, but the colostrum from the cow was much richer in this vitamin. The Minnesota station has not been able to maintain normal vitamin E values in the blood of calves when lard or corn oil was substituted for butterfat during the milk feeding period.

The New York (Cornell) station (coop. USDA) fed a supernormal, a normal, and a subnormal diet to three different groups of calves. At 2 years of age the calves fed the supernormal ration weighed 1,020 pounds, whereas those on the subnormal diet weighed only 700 pounds. The calves (heifers) on the supernormal ration became sexually mature at 9.4 months and those fed the normal ration at an average age of 11.3 months, but the underfed group did not mature sexually until they were 17.3 months of age. There is a distinct difference between

securing maximum skeletal growth or early sexual maturity and fattening the calf.

Heifers maintained by the Missouri station from birth to producing age in a fat condition did not produce up to their predicted milking capacity until their third lactation. But underfed heifers, according to the New York (Cornell) station, lack the best udder development. The Nebraska station attempted to fatten young calves by feeding 12 to 15 grams of thiouracil to slow down thyroid activity, but without success.

Physiology of Dairy Animals

Results at the West Virginia station contradict the traditional notions with respect to the advantages and disadvantages of prepartum milking. The station found that prepartum milking did not decrease udder congestion or edema, or cause cows to reach their peak of production more quickly. The station also disproved the idea held by some that prepartum milking makes calving more difficult, increases the frequency of retained placenta, or has an injurious effect upon the calf. Montana research on the effects of prepartum milking showed that cows which respond to prepartum milking (with increasing amounts of milk) almost never have milk fever after they freshen. Instead of milking cows before freshening to reduce inflammation of the udder some authorities have recommended moderate exercise for the cow up to the time of calving. But results at Kansas indicate that walking as much as 2 miles per day did not reduce the edema in the udder. Missouri scientists have discovered that during pregnancy the mammary gland elaborates an enzyme which liquefies the connective tissue so the growing secretory tissue will have plenty of room.

DAIRY MANUFACTURING

Rapid strides are being made in research designed to improve the methods of manufacturing and distributing dairy products. Studies in the experiment station dairy laboratories have resulted in major advances in the making of higher quality products, preserving them over longer periods of time and distances, and avoiding spoilage.

New Test for Rancidity

The California and Pennsylvania stations recommend a new chemical test for detecting rancidity of milk fat. The reagent used is 2-thiobarbituric acid (TBA). The compound which produces the rancid flavor has been tentatively identified by the Pennsylvania station as malonic dialdehyde. The new test is applicable not only to milk fat but to a wide variety of animal and vegetable fats. It should be particularly useful in determining the storage life of any fat-containing food.

The Iowa station found that milk fat contains relatively small amounts of tocopherol (10 γ to 45 γ per gram), whereas vegetable fats used in oleomargarine manufacture are rich in tocopherols (450 γ to 750 γ per gram). With this information it is possible to detect as little as 5 to 10 percent adulteration with vegetable fat in milk fat.

The Pennsylvania station has succeeded in eliminating the con-

ventional steps in the preparation of butter oil. By adding such surface-active agents as Tergitol 7 or Ahcowet-RS, it was possible to quickly break the natural oil-water emulsion in milk and obtain a high quality butter oil.

Water-Insoluble Acids in Butter

Much attention has been given to developing a simple accurate method of determining the WIA (water-insoluble acids) in butter, since the amount of these acids is now serving as an index of the quality of cream used in the manufacture of commercial butter. The Indiana station found that the WIA reading is influenced as much as 100 percent by the amount of alkali used in neutralizing the ether-water solution in the present test.

The Illinois station calls attention to the fact that added glucose markedly reduces the rate of WIA formation in cream. The station inoculated sterilized cream with *Geotrichum candidum* and found that between 4° C. and 37° WIA formation was in direct proportion to the incubation temperatures but that lactic acid inhibited the production of water-insoluble acids. A sample of cream which soured rapidly generally contained less water-insoluble acids than a sample of cream in which acid developed slowly. The assay of samples by both the newly recommended method and by the earlier Hillig method indicated that some error results from variation in butterfat color.

By adding formaldehyde to suppress microbial growth, the Iowa station demonstrated that the natural milk lipase causes an increase in both WIA and butyric acid values. Holding cream at low temperatures may prevent acid defects as a result of bacterial action, but increased fat hydrolysis occurs owing to stimulation of lipase activity. Knowledge of these factors which alter the rate of formation of WIA should assist creamerymen in producing more marketable butter.

Dairy technologists at the Kansas station noted that cream separated from milk known to be susceptible to spontaneous oxidation had lower WIA numbers than cream from milk that did not develop an oxidized flavor. The Nebraska station found that organoleptic grading of cream did not consistently result in a high or low WIA value. Usually the WIA content of butter was slightly lower than the WIA content of the cream from which it was churned.

Expansion of the cream layer of fluid milk by the illegal practice of adding reconstituted superheated condensed milk depends on the presence of fine curd floccules in the cream. The Oklahoma station demonstrated how this fraud can be detected and what changes in the cream line can be brought about by different techniques.

No difference in the growth-promoting properties of milk fat from different breeds or from cows fed on different rations were discovered in an experiment carried on by the California station. A slight difference was found when the fat was fractionated into three portions by precipitation from a solvent at -20° F., -53°, and filtrate remaining at -53°. Rats fed the -53° filtrate generally showed greatest growth, and those fed the -20° fraction the least gains. Substituting a 2-percent linoleic acid for an equal amount of -20° precipitate did not improve its growth-promoting properties.

Better Cheese-Making Methods

Recent research indicates that some of the most desirable flavor characteristics of cheddar cheese have been due to "minority" bacteria which are destroyed when pasteurized milk is used for the making of cheese. The Wisconsin station found that certain strains of *Micrococcus freudenreichii* which grow in competition with *Streptococcus lactis* bacteria supplied in the cheese starter, greatly improved the flavor of pasteurized milk cheese and shortened the time for proper flavor development from 8 to 11 months to 2 to 4 months.

Dairy chemists at the Illinois station carefully analyzed cheddar cheese in order to learn the kind and amounts of amino acids liberated during the curing process and the relation of each to the flavor of the cured product. Glutamic acid, leucine, and isoleucine were the first amino acids to be detected in the cheddar cheese curd. At the end of a 4-month period, 12 amino acids and 2 amines were present.

A substantial portion of the characteristic flavor of blue cheese is due to methyl ketones, according to the Pennsylvania station. These compounds apparently are formed from β -oxidation of milk fat acids by penicillium mold. A synthetic blue cheese flavor concentrate has even been prepared from methyl amyl ketone and butyric acid. The Minnesota and Wisconsin station together developed a type of mold (white mutant of *Penicillium roqueforti*) that gives Roquefort cheese its characteristic flavor but is colorless. This new mold has stronger proteolytic activity and less lipolytic activity than other molds, which should improve the flavor of the cured cheese.

The Wisconsin station developed a method of producing stirred curd cheese which has the desired body, texture, flavor, and color. In addition, the time spent on a vat has been reduced by this method from about 2½ hours to 45 minutes.

A very desirable cottage cheese from skim milk supplemented with condensed skim milk and non-fat dry-milk solids has been made by the California station. Similarly the Minnesota station had good success in manufacturing cottage cheese from reconstituted non-fat dry-milk solids, provided the denatured serum proteins (caused by heating in processing) did not exceed 6 percent.

Inhibiting Bacteriophage

Cheese plants continue to encounter starter failure. Plant operators frequently blame the failure of their starters to the careless use of antibiotics or detergents by milk producers. The Oregon station has found, after tracing down many of these complaints, that bacteriophages are probably the most important cause of starter failures. It has been possible in many instances to eliminate the phage trouble by the use of germicides recommended by the station workers. The Oklahoma station found that concentrations of 1½ to 2 percent salt (NaCl) added to milk apparently inhibited the most troublesome types of bacteriophage. The salt had little influence on the growth of *Streptococcus lactis*. The California station has shown that the number of bacteriophage particles in a starter must be extremely small if the lactic acid organisms necessary for the normal production of acid are to have opportunity to develop before being destroyed by the bacte-

riophage. According to the Minnesota station, the more phage-resistant strains of lactic acid producing streptococci have more complex nutritive requirements (amino acids and vitamins).

The Iowa and Georgia experiment stations found that aerosols of calcium hypochlorite supplying 0.61 gram of available chlorine per 1,000 cubic feet of air completely inactivated the air-borne phage within 10 seconds. An aerosol supply 0.7 gram of alkyl dimethyl benzyl ammonium chloride per 1,000 cubic feet failed to inactivate the phage and was intolerable to a person in the room.

Smoother-Bodied Ice Cream

The development of "sandiness" in ice cream of less than 15 percent milk solids-not-fat was prevented at the California station by "seeding" the ice cream with powdered lactose during the freezing process. The seeded ice cream had a richer flavor than unseeded ice cream of the same composition. The Michigan station claims that ice cream produced by a continuous freezer has a smoother body, the ice crystals are smaller, and the melt-down is slower than when frozen in a batch freezer.

The Minnesota station showed that the age thickening and browning of high-quality sweetened condensed skim milk has no significant influence on shrinkage susceptibility of ice cream. Evidence was also obtained that replacement of up to 35 percent of sucrose in the mix by dextrose does not significantly affect shrinkage susceptibility.

The Georgia station recommends that soft ice cream contain at least 6 percent milk fat, 11.5 percent milk solids-not-fat, 14 percent sugar, 0.3 percent stabilizer, and 0.1 percent emulsifier.

Condensed and Powdered Milk

The Pennsylvania station has continued to study the chemical changes induced in milk by high temperature treatment. Hydroxymethylfurfural has been identified as one of the compounds formed during prolonged heat treatment of concentrated skim milk. The lactose in the milk was identified as the source of furfuryl alcohol and maltol, two other undesirable products resulting from high heat treatment of milk. Presumptive but not conclusive evidence that acetaldehyde is formed during the heating of milk was also obtained. The station has also been concerned with flavor deterioration of whole milk powder. It has evidence that flavor deterioration begins in the low melting portion of the butterfat.

Raising the temperature of stored whole milk powder from 45° F. to 85° at the Washington station lowered the wettability (a desired quality) from about 80 percent to about 30 percent in 1 week. But wettability could be very nearly restored by subjecting the powder to a high vacuum for 1 hour in an oven at about 140°. The station also reports that the stearic acid esters and poly-oxyethylene derivatives are equal if not superior to nordihydroguaiaretic acid (N. D. G. A.) as antioxidants in prolonging the storage life of whole milk powder.

Sodium tetra pyrophosphate and sodium tripoly phosphate stimulated the germicidal activity of certain quaternary ammonium compounds (QAC) more than twenty-fold, according to research at

the Oregon station. A new QAC (alkyl dimethyl ethyl benzyl ammonium chloride) had about twice the germicidal activity of any other QAC on the market when tested in water lacking inhibitory calcium, magnesium, and iron ions, but its activity was markedly inhibited by hard water salts.

POULTRY RESEARCH

The previous sections on marketing research have included several prominent examples from the poultry industry. Poultry raising and marketing are so closely related that a new development in one is bound to affect the other. Whether their chief interest lies in the laboratory, the laying pens, the broiler house, or the egg and poultry market, poultrymen as a group generally grasp the significance of a new practice and join hands to promote it, once it has shown its worth. Industry-wide cooperation has had much to do with making income from poultry a sizeable stake in the national farm total. In 1950, total income from chickens, eggs, and turkeys, including products consumed in farm households, amounted to \$3,190,139,000. Of this total income, eggs contributed 56.5 percent; farm chickens, 18.8 percent; broilers, 16.2 percent; and turkeys, 8.5 percent. A business of such volume demands and is getting a prominent place in the research of experiment stations directed at production problems. Especially in times of all-out Nation-wide economic effort, like that required in defense preparations, no possibility is overlooked to help poultry farmers contribute all they can to the Nation's meat and protein supplies.

Breeding Better Birds

Durhams and White Durhams

About 10 years ago the New Hampshire station looked into the possibilities of using Cornish blood in producing better broilers. The Cornish breed has excellent meat qualities but is normally very inferior in egg production, hatchability, growth, feathering, and other economic factors. The New Hampshire breed, on the other hand, possesses most of these qualities except for the desired breast width. Therefore, Dark Cornish males were crossed on New Hampshire females and a new breed now called Durham was developed. For 10 years new generations have been carefully selected in order to eliminate undesirable traits. Although the new breed still retains such Cornish features as slow growth, close feathering, and dark hairs, it is used to advantage in crossing with New Hampshires. The cross results in birds with considerable more weight when compared with the Durham; it is about equal in quality to the straight New Hampshires and it retains many of the excellent breast qualities featured in the Durhams.

The station is now also carrying on research with a White Cornish \times New Hampshire cross which is expected to eliminate the dark hairs and result in a more desirable bird for the market. This breed is called White Durham. Its plumage varies in color from all white to buff and some individuals have streaks of red and white. This new breed retains the excellent breast width of its Cornish ancestor.

Improved Management

Saving labor for the poultryman

Daily labor requirements for feeding, watering, and egg-gathering were determined by the Pennsylvania station on 10 poultry farms in the State. Time and travel records were taken before and after making specific changes in methods and facilities over a 16-month period. The replacement of scattered small laying pens with larger units in a more orderly compact arrangement; the removal of partitions between pens; the grouping of nests near the pen doors, or the addition of nesting rooms; the installation of floor feed-boxes with overhead chutes, or, in the large units, of a mechanical mash feeder; and the use of feed carrier tracks and frost-protected automatic waterers—all proved to be valuable as labor and timesavers.

The Pennsylvania station is now experimenting with a specially designed utility unit consisting of an automatic feeder and waterer installed between the roosting perches so that the chickens eat, drink, and roost over a droppings pit. A mechanical cleaner is used daily to move the droppings from the pit. This system frees the floor of hoppers and drinking equipment, simplifies servicing, and reduces the amount of droppings voided on the floor, so that the moisture content of the litter stays 16 to 21 percent lower than that in a pen with standard arrangements. Cleanliness of eggs as measured by time required for cleaning is reflected by this low moisture content.

Reductions in costs made possible by this research total more than a million dollars. The universal removal of partitions, rearrangement of nests, and installation of water fountains throughout Pennsylvania would allow a saving in labor of possibly \$250,000 per annum. Automatic feeders would provide a saving in feed of as much as \$115,000 with layers, and \$350,000 with broilers. In addition, time saved in the care of broilers by the use of automatic feeders would easily be worth \$300,000 annually.

Old built-up litter disastrous for turkeys

The Ohio station conducted an experiment to determine whether turkeys raised on old built-up litter develop resistance to blackhead. In pens with old, previously used turkey litter, the mortality was 67.5 percent; where old chicken broiler litter was used, the mortality was 96.7 percent; where new built-up turkey litter was used, 25 percent; and where new litter was used and changed weekly, 15.8 percent. The oral administration of the new drug, Enheptin-T (2-amino-5-nitrothiazole) reduced the mortality to 10 percent, of which only 2 percent was from blackhead. The research indicates that the use of old litter in the turkey brooder house would prove disastrous. Good litter management with turkeys requires that fresh litter be used and changed frequently.

Nutritional Achievements

Hormonal effects on poultry production

Hormones are chemical substances produced in organs of the body, which, being carried to an associated organ by the blood stream, excites in the latter organ a functional activity. In recent years a number of the hormones have been produced artificially in the chem-

ical laboratory. In some instances this synthetic process has resulted in the inexpensive production of these hormones and hormone-like substances. This in turn has encouraged research by the State experiment stations and the Department to find uses for them in the more efficient production and increased quality of both chickens and turkeys.

CAUTION ON FEEDING OF FEMALE SEX HORMONES.—**In most of the research with hormones the administration is by way of mouth. Nevertheless, inasmuch as the possibility exists that orally administered estrogens (female sex hormones) may be stored in the tissues of birds in sufficient amounts to affect the consumer, the commercial feeding of estrogens to poultry is not yet permitted by the Food and Drug Administration. However, the implantation of 15-milligram estrogen pellets into the neck tissue at the back of the head of poultry, has been permitted.**

In experiments with 48 different estrogenic compounds, the Oklahoma station found that practical procedures for feeding synthetic estrogens to broilers to improve meat quality can be recommended *whenever estrogen feeding is approved for commercial use*. Implantation of estrogenic pellets in birds is more costly and less effective than including an estrogen in the feed. Estrogen feeding at this station has produced 87 percent Grade A broilers as compared with 58 without the hormone, 95 percent Grade A old cocks as compared with 58 without the estrogen, and 92 percent Grades A and B turkeys as compared with 74 percent without the estrogen. The deposition of fat was hastened, flavor improved, skin bleached, and pinfeathers eliminated by the treatment.

When protamone, a synthetic material having thyroid activity, was fed to poultry at the Texas station for the first 6 weeks, and then followed by a combination of thiouracil and of an estrogen for 4 weeks, the resulting fryers were as large or larger than the controls, exceptionally high in quality, unusually fat, and very soft meat. Only about one-half the usual time was required for frying, and the dressing loss was decreased. Feeding surplus breeding cockerels for 6 weeks on the above-mentioned combination brought gains almost twice that of controls, 4 percent decrease in dressing loss, and carcasses of unusually good quality.

According to the Missouri station the feeding of thyroprotein to White Rock laying hens stimulated egg production during the periods of normal drop, and maintained good shell quality in the summer. Apparently the secretion of the thyroid glands in the heavier breeds developed for broilers may limit their egg-producing ability. Thus, when this limitation was corrected by thyroprotein feeding, egg production increased to a point where the production of the Rocks compared favorably with strains especially developed for production.

According to the Oregon station, the hormone prolactin can be used as a test for broodiness. Two cockerels may be of the same strain and look equally masculine, yet one may impart broodiness to the breeding flock through the inheritance of a gene for broodiness, whereas the other would not. To determine the undesirable one, each is given a daily injection when 10 months old of prolactin in the breast for a week or less. The cockerel that can withstand the most hormone without developing a motherly attitude toward a brood of chicks and clucking like a hen, is the one most likely to father

hens that will lay eggs instead of wanting to hatch them. There is no carryover effect of the hormone, and cockerels become normal within 3 or 4 days after injections cease.

With turkeys hormones feeding is effective also. The Maryland station improved market quality of birds on less feed per bird with a combination of thiouracil and thyroprotein, and the Oklahoma station obtained a better finish and pinfeather condition of turkeys in hot weather under normal range conditions, by supplementing the mash with either triphenylchloroethylene or triphenylbromoethylene.

Mystery of growth response from antibiotics

The astounding response of both birds and mammals to the inclusion of antibiotics in their diet opens up a new and intriguing field for exploration by the nutritionists of both the State stations and the Department. Research at the Michigan station indicates that the growth response in chicks is obtained through the oral route and not by injection, and may therefore be considered an indirect response, mediated in some manner through changes taking place in the intestinal tract. These changes involve the growth of bacterial cells and perhaps the permeability of the absorption surface, since it has been shown that many of the antibiotics are surface active. Bacteriological studies, however, have not revealed specific changes in intestinal bacterial types as a result of feeding antibiotics, that could be correlated with a growth response.

Research is now being conducted with quarternary ammonium compounds to determine what effect a change of surface tension might have on growth. In a preliminary study, the inclusion of a well-known commercial detergent in the diet gave an increase in growth slightly below that obtained from antibiotics, but the results are still inconclusive. The oral administration of antibiotics has led to increased storage of vitamin B₁₂ and biotin in the liver, and has brought about a greater turn-over rate of radioactive phosphorous and cobalt in both liver and bones.

In connection with its antibiotic research, the Michigan station discovered that a marked interrelationship exists between vitamin B₁₂ and pantothenic acid. In a state of B₁₂ deficiency, the chick stores large amounts of pantothenic acid in the liver. When the deficiency is corrected, pantothenic acid liver values are lowered significantly.

Vitamin B₁₂ involved in protein metabolism

The Colorado station has found that the blood levels of a number of amino acids, including arginine, histidine, lysine, threonine, and valine, are increased in vitamin B₁₂ deficiency. This indicates that one of the functions of vitamin B₁₂ is concerned with protein metabolism. As the level of protein in the diet is increased, the requirement for vitamin B₁₂ also is increased.

The Maryland station has shown that the addition of glycine, leucine, or zein to a ration low in vitamin B₁₂ will markedly depress growth. This growth depression is completely overcome by the addition of vitamin B₁₂. Other amino acids have been tested with less marked effects. At the same time the deficiency of vitamin B₁₂ results in increased blood levels of nonprotein nitrogen, amino nitrogen, uric acid, urea, creatinine, and blood sugar. Since corn protein (zein) and soybean oil meal are relatively high in leucine and glycine,

respectively, these findings are of practical as well as fundamental significance. In research on the protein requirements of chickens, whose ability to synthesize vitamin B₁₂ by bacterial action in the intestinal tract appears to be quite limited, it is necessary to be certain that the quantity of vitamin B₁₂ provided is adequate for all the levels of protein used.

Effect of xanthophyll on vitamin A absorption

Xanthophylls, golden yellow pigments occurring widely in plants, when incorporated into poultry rations at the Arizona station (coop. USDA), produced chickens with bright yellow legs and skins, and eggs having deep yellow yolks. Inasmuch as it has been reported that these pigments lower the utilization of vitamin A in rats, the Arizona station ran tests to determine whether the same effect occurs in chickens. When only the optimum amount of carotene was fed daily (65 micrograms) there was no decrease in vitamin A storage caused by a daily supplement of either 100, 300, or 600 micrograms of the xanthophylls. However, when the amount of carotene fed was doubled, xanthophylls decreased the storage by 38 to 32 percent, even when the vitamin A precursor was administered in three doses 3 hours apart. The findings show that under practical conditions where excessive amounts of carotene or vitamin A are not fed, xanthophylls will not affect the vitamin A requirements of chickens.

Diet of parent stock affects broilers

Through research an effort is being made to bring more profits to the broiler industry by means of improvements in the diet of the parent stock as well as of the broilers themselves. Last year the Arkansas station studied the requirements for the vitamin B₁₂ supplement (vitamin B₁₂ plus other undetermined growth factors—called until recently, animal-protein-factor or APF) of hens representing strains of four different breeds of chickens, that would insure optimum hatchability of their eggs, and the carry-over of the growth factor or factors to the progeny. The results indicate that there is a strain difference in the vitamin B₁₂ supplement requirement of hens for egg hatchability. The growth rate of the progeny suggests that the percentage of fertile eggs hatching is not a measure of the degree of the carry-over of the growth factor or factors to the chick.

Chick diets were formulated with a high-protein soybean oil meal (50 percent protein) replacing the 44-percent product usually fed. This more highly concentrated ingredient permitted the formulation of diets containing larger amounts of cereal grains. Three different types of diets were prepared and in each case the use of high-protein soybean oil meal resulted in an increased growth rate and feed efficiency. These studies made possible the development of chick diets that will produce a broiler on one-half pound less feed than will previous standard rations.

Poultry Physiology

Time of hatching affects sexual maturity

In a study involving 1,372 New Hampshire, White Leghorn, native, and crossbred pullets during a period of hatching extending from January to June, the Puerto Rico station found that time of hatching

has an important bearing on sexual maturity and egg production of pullets. This is true regardless of the relatively uniform climatic conditions on the Island which have no seasonal extremes. Female chicks hatched in February had earlier sexual maturity than those hatched in March. In most of the groups studied, birds hatched in May had earlier sexual maturity than those hatched in April. The results were more pronounced than those developed in tests made under conditions in the States. The poultry breeder in Puerto Rico, therefore, must consider a correction or allowance for date of hatch when selecting for early sexual maturity; otherwise he would be selecting for an environmental effect instead of for the genetic make-up of the birds. February is apparently the best month from this standpoint.

Disease resistance associated with reticulo-endothelial system

The reticulo-endothelial system, which includes cells of the spleen, lymph, liver, bone marrow, connective tissue, and hemolymph glands, is concerned with blood-cell formation, bile formation, the staining of fatty materials, phagocytic (white cell) destruction of blood cells, and the metabolism of iron and pigment. On the theory that this system can filter congo red particles from the blood stream in very much the same manner as disease-producing viruses, the Alabama station has conducted 17 tests to compare the ability of different breeds of chickens to filter out such particles. One cubic centimeter of a 0.5 percent congo red dye was injected into the blood stream of the birds through the brachial wing vein. Blood from the heart was removed at 4 and 60 minutes after the injection. The disease-resistant Auburn strain of White Leghorns (see Report on Experiment Stations, 1949, p. 56) was able to reduce the congo red in the blood stream by 3.67 milligrams per 100 cubic centimeters of blood in 56 minutes, whereas corresponding figures for susceptible White Plymouth Rocks, New Hampshires, and Rhode Island Reds were 2.28, 2.49, and 2.51, respectively. Thus if it can be established that disease resistance is associated with the reticulo-endothelial system, breeding schedules can be more systematically planned.

Low temperatures injure turkey sperm

About 20 percent of the Broadbreasted Bronze hatching eggs identified as "infertile" by the cooperating commercial hatcheries, were found by the Washington station (coop. USDA) to be instances of early arrested embryonic development. Growth stopped sometime during the first 36 hours of incubation. Certain types of blastoderms (the delicate innermost living membrane of the impregnated egg) have been identified as "moribund," incapable of normal development. Low temperatures which prevailed in Pullman, Wash., during the winter and early spring months of 1949-50 had a definite detrimental effect on the reproductive capacity of the Broadbreasted Bronze toms. Hatching eggs from Bronze hens were considerably more susceptible to the effects of preincubation storage than those from Beltsville Small Whites. The fact that the Bronze toms apparently respond to a more optimum temperature environment by increasing their reproductive efficiency, suggests a way for improving the total hatchability of the Bronze eggs produced under commercial conditions. The present hatchability average for turkey eggs is 50 percent.

Assume that 2 million hatching eggs have been set in a particular year. An increase in the hatchability average of as much as 10 percent would bring more than \$140,000 in additional returns to the turkey-hatching industry.

VETERINARY RESEARCH

The fight against diseases, parasites, and conditions that adversely affect animals and that directly or indirectly affect the health and welfare of man, is a continuous one. Veterinarians and those in allied fields are constantly teaming up against these economic and health hazards which are an ever-present threat.

During the year as studies in these fields have progressed, numerous articles, both technical and popular, have taken research results directly to those who are interested and have thus permitted them to get immediate practical application.

The examples which follow illustrate some of the research now in progress in the field of veterinary medicine.

Radiation—a possible weapon against trichinosis

The Hawaii station has studied the effects of radiation on *Trichinella spiralis*, the causative agent of swine and human trichinosis. This important parasitic disease of hogs is usually spread to man as a result of eating meat from affected swine, which has not been sufficiently cooked. A conservative estimate shows that approximately 16 percent of the human population of the United States harbors the parasite. The radiation dosage (roentgens) necessary to make it impossible for the parasite to produce young, and thus to insure the susceptible host against muscle infestation, and also the amount needed to render encysted trichinae larvae in meat inactive and incapable of developing further in the host, has been found. These studies open the way for possible use of radiation in the sterilization of pork and other meat products against parasitic infestations.

Control of the swine kidney worm

The damage caused by the swine kidney worm, *Stephanurus dentatus* Diesing, 1839, has created an important economic problem for the swine raisers in the Southern States. The mature kidney worm is about 2 inches in length and one-sixteenth inch in diameter. It is found in the kidneys and in thick fibrous tissue cysts in the perirenal fat. The cysts open into the kidney and ureters, and kidney worm eggs pass from these cysts into the kidney, ureter, and bladder to be voided with the urine. As many as 500,000 to 1,000,000 eggs may be passed daily by a moderately infected sow. The eggs hatch in 24 to 48 hours, and the larvae become infective in 3 to 5 days under ideal conditions of temperature, shade, and moisture.

The annual economic loss caused by this parasite has been estimated at between \$3,000,000 and \$5,000,000. These losses are due to inefficient utilization of feed by infested swine and to condemnation of portions of affected carcasses including livers, kidneys, and other tissues of affected animals, found unsuitable for food.

As a result of studies at the South Carolina station, the delta isomer of benzene hexachloride may prove to be an important aid in the control of the swine kidney worm.

"X-Disease (*hyperkeratosis of cattle*)"

Mention was made of this malady in the 1948 report in which it was pointed out that a somewhat baffling condition recognized in New York in 1941 had since appeared in other parts of the country and was responsible for heavy losses in affected herds. The Department initiated cooperative action with States of the several regions, and studies were set in motion to determine whether or not the condition is caused by faulty nutrition, toxic substances, or perhaps an infectious agent.

The disease is characterized by profuse watery discharges from eyes and nose in the earlier stages, followed by loss of appetite and condition, depression, and thickening and wrinkling of the skin ("elephant hide"). Pregnant animals may abort, diarrhea may be present—particularly in the later stages—and papillary projections may occur on the surfaces of the tongue, cheek, and palate.

The study has now been narrowed to two phases—one, investigation of the chemical nature of a toxic agent found to be a possible cause; two, study of an apparently infectious agent, which in some respects causes a similar condition, but which may or may not be a direct or associated cause of this disease.

This is an outstanding example of the value of coordinated attack and group action in bringing about more complete understanding of a condition in a relatively short time so that practical measures for its control may rapidly be found.

The following 16 stations are cooperating with the Department in attacking problems related to X-Disease: Alabama, Colorado, Storrs (Connecticut), Georgia, Illinois, Indiana, Kansas, Michigan, Montana, Nebraska, New Jersey, New York (Cornell), North Dakota, Pennsylvania, Tennessee, and Texas.

Plant materials as antibiotics

Biological warfare in one form or another is and has been part and parcel of life since the beginning of time. Nature must strike a so-called balance, otherwise certain species would take over to the ultimate detriment of all. This principle may be demonstrated throughout the entire scope of agricultural research. One way of employing the principle to man's advantage has received wide usage and acclaim during recent years. This is the discovery and use of antibiotics for allaying ills of man and animals. A number of stations are working in this important field.

During the year the Puerto Rico station reported that alcoholic extracts from leaves of maney (*Mammea americana*) and the flowers of jaxmin frances (*Moringa moringa*) are active against *Brucella abortus* in laboratory tests. According to preliminary tests with mice some protection is afforded against a lethal dose of *B. abortus*. The extract retained its activity after standing at room temperature for 6 months. Of the extracts from 299 plants native to Puerto Rico, 29 were shown to contain an antibiotic substance active against one or more of 12 virulent organisms tested.

Pneumonia in sheep

A nonbacterial transmissible agent has been isolated from pneumonic lungs of sheep by the Michigan station. By growing the agent on membranes of developing chick embryos, it has been possible to describe in detail its effects on the embryos, particularly pneumonia produced in the embryonic lungs. Further tests indicate the agent is

possibly a virus. This is an important study which, as it progresses, may serve to change the present theories with respect to the causes of pneumonia in sheep.

Mastitis control

Many bactericidal and cleansing agents have been recommended for use in solutions for washing udders of cows before milking in an attempt to control the spread of mastitis in dairy herds. The Pennsylvania station compared the effectiveness of control obtained when these materials are used and when clean water alone is used. Comparison of two concentrations of chlorine and one of quaternary ammonium compound with clean water as a wash for udders showed that all of them were equally ineffective in preventing the spread of organisms associated with mastitis.

The Pennsylvania station has obtained additional information also on the proper sampling procedures to follow in determining the degree of streptococcal infection in that type of mastitis. The first and second samples (15-ml.) of milk drawn were the most reliable for testing. In fact, some infected quarters would not have been detected if these first samples had been passed by and only midmilk or stripplings used as a basis for the tests.

The Florida station found that milk cows treated with penicillin or aureomycin retained these antibiotics through the fourth and twelfth milkings, respectively. Heat or cold had little effect on either antibiotic.

The Michigan station points out that promiscuous use of antibiotics in the treatment of mastitis and failure to withhold from sale the milk from treated quarters result in trouble for the dairy manufacturer. The unknown presence of antibiotics is responsible for spoiling large batches of milk for commercial purposes. This loss is directly reflected in the price of the milk paid to the dairy farmer.

The Michigan research indicates that milk from such treated quarters should be withheld from the main supply for at least 3 days, since pasteurization of milk does not destroy the antibiotics commonly used in the treatment of infectious mastitis. Another important reason for withholding such milk from sale is that the ingestion of penicillin in milk by human beings may affect adversely those who are sensitive to this antibiotic. The use of antibiotics alone without good sanitary milking and herd management procedures will not control mastitis.

***Brucella suis* as a cause of mastitis**

The Indiana station produced severe mastitis in cows by inoculating them with living *Brucella suis* via the teat canal. The organisms persisted and were recovered from the milk in some cases as long as 4 months following exposure. Milk from affected quarters was definitely altered. Following the acute stage, in which affected parts of udders were swollen, reddened, and tender, the inflammatory reaction gradually subsided and changes of a progressive nature and an increase of connective tissue took place. The results of this study point to the possibility that *B. suis* causes udder damage.

Possible control of calf scours

Preliminary studies at the Pennsylvania station give hope that aureomycin administered orally may control losses from calf scours. This is based on observations of 13 calves which were born during an

outbreak of the disease. Each of the calves was given aureomycin tablets at birth. Nine of the calves failed to develop scours. Four responded favorably to a second oral treatment. If repeated trials of the Pennsylvania treatment continue to prove it effective in preventing development of scours in very young calves, it will provide a more practical solution than those now in use.

Baby pig losses

An effort has been made by the Illinois station to determine what at times causes large numbers of newly born pigs (in one instance nearly 50 percent of those farrowed) to die from uremia caused by urinary waste products—uric acid and urea-nitrogen values—in the blood.

Since data concerning this condition in swine are limited, it was important to obtain more information about biochemical changes associated with uremia. This phase of the station's general study of baby pig disease has been completed. Uremia has been experimentally produced by obstructing the flow of urine from the kidneys (by ligation of the ureters) in pigs ranging in age from 3 to 82 days. As a result factual information is available on anatomical and functional changes in the kidneys and biochemical changes which occur in blood. In general, the main clinical symptoms noticed with this condition in pigs is apathy, drowsiness, weakness, and coma. Neither vomiting nor convulsions were observed.

False security in cattle parasite control

If findings of the Louisiana station are confirmed by additional tests, they will indicate that there is a high degree of false security associated with the method of administering phenothiazine by mixing it with salt to which animals are given free access. This station reports that the amounts of a 1-to-10 phenothiazine salt mixture consumed by each animal at any one time or during different time intervals varied greatly. These observations indicate that the amount of the drug thus consumed would not be effective in controlling nodular and hookworm infestations, since it is below the minimum requirements.

Coccidiosis in turkeys

Coccidiosis in turkeys has been demonstrated by the Michigan station to be caused by at least four species of the parasite, one of which is described as a new species. Changes or damage caused by each of these has been described as well as their developmental forms in the life history. Immunological studies show that each of the species, when used in turkeys, would produce a specific resistance (protection), which makes possible practical prevention of the infestation caused by each.

Reproductive disorders in sheep and cattle

Vibrio fetus infection in sheep and cattle apparently is quite widespread and is receiving considerable study at several stations in connection with investigations of reproductive disorders.

In studying vibronic abortion in ewes the Wyoming station has found that under laboratory conditions certain antibiotics, neomycin, terramycin, and chloromycetin, are active against *Vibrio fetus*. This indicates that it may be possible to use them in helping control the

disease in sheep as well as in cattle. This, of course, will have to be established by tests of affected animals.

Data analyzed on 5 to 25 herds tested periodically by the Storrs station (Connecticut) indicate that losses from lowered conception rates and sale of cows because of "sterility" caused by vibriosis are as important as losses from detectable abortions. According to studies at this station intrauterine infusion with streptomycin appeared to be effective in overcoming apparent sterility caused by *Vibrio fetus* in three herds. The Storrs station also reports improvement of the agglutination test for this disease which is an important additional aid in definitely diagnosing the causes of abortions and reproductive failures and provides the basis for research on ways of controlling reproductive failures in cattle.

Newcastle disease research

The research on Newcastle disease is another example of what may be done when research workers pool their efforts in an attempt to control a serious disease that threatens an entire industry. Already the results of work by men at stations scattered throughout the four regions of the country, in cooperation with the Department has made it possible in many areas for those engaged in poultry raising to stay in business. Research in Newcastle disease is now integrated through an interregional committee and through a free exchange of technical information all poultry disease investigators are kept fully informed.

A repository for the storage and detailed study of so-called "strains" of Newcastle virus has been established at the Wisconsin station. A number of different types of vaccine have been made including Hamster "rodent" adapted strains, strains passed through birds other than chickens, and the strain of low virulence "B₁" used intranasally in poultry. Studies have been conducted and are being continued in all the major phases of Newcastle disease, such as the diagnosis, spread of the disease, immunization, virus reactions, and sanitary procedures for the control of this disease.

It may seem logical to ask why such studies should be continued when vaccines are at hand for control of the disease. The ideal vaccine, which produces a strong and lasting immunity without upsetting the birds and that does not constitute a danger to unvaccinated birds, is yet to be found, and only by continuous and painstaking research will it be discovered. Also, it is recognized that the use of living Newcastle vaccine will not end the threat of the disease and will not eradicate it. There is no example in the history of human or veterinary medicine of a vaccine that alone has eliminated disease. Meanwhile, best use is being made of what is available and improvements are in progress.

For instance, the Virginia station announces that vaccination by nebulization (spraying) with B₁ vaccine is practical and safe. In comparison with the old procedure of dropping the material in chick nostrils, this method has unlimited possibilities in large-scale handling of chicks and should effect savings in labor and other expense. Preliminary research at the Massachusetts and Texas stations support the results obtained at the Virginia station.

Another reason for continued research on Newcastle disease is the fact that other respiratory diseases of poultry are apparently on

the increase and are of such a nature that it is often difficult to distinguish them from Newcastle. They are often the cause of trouble in Newcastle-vaccinated flocks, and produce symptoms that are so similar to Newcastle disease that farmers feel they are suffering a "break" and blame it on the vaccine. These diseases are now receiving intensive study under a revised program which provides for the investigation of *Newcastle and allied respiratory diseases of poultry*.

The following stations are studying these problems (coop. USDA): California, Storrs (Connecticut), Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York (Cornell), North Dakota, Ohio, Rhode Island, South Dakota, Texas, Virginia, West Virginia, and Wisconsin.

BETTER DEFENSE AGAINST INSECTS

Experiment station research in entomology continued to make advances and notable economic contributions. An example is the 1951 story of cotton production. In 1950 damage to cotton by insects was severe. In one State, where it was unusually bad, a sample survey showed an average yield of only 229 pounds of seed cotton per acre from untreated fields as compared with 1,272 pounds from fields treated with insecticides. Even though effective control measures were known and were used in many places, more than one-quarter of the cotton crop in the central and eastern sections of the Cotton Belt was destroyed by insects. Domestic and military requirements called for a greatly increased production in 1951.

To meet this situation the latest know-how on the control of insect pests and the use of seed, fertilizer, machinery, and labor, developed by the research of the State experiment stations and the Department, was presented to cotton farmers in an educational campaign carried out by the cooperative extension services. Cotton production was increased in 1951 by more than 5 million bales over the previous year. Although much of this was accomplished through an increased cotton acreage, the information developed in research on insect control played an important part in reducing losses in 1951.

Some of the fields of entomology in which research is moving forward rapidly include the better use of insecticides and better methods of applying them; and better and more economical control of cotton, fruit, and meadow crop insects. Control of insect pests of hay and pasture and methods of encouraging the activity of pollinating insects are receiving special attention. Such research can improve grassland production, as illustrated by the results on spittlebug control reported by the Ohio station. Following are a few representative accomplishments of research in entomology reported by State experiment stations.

Pelleted insecticides control mosquitoes

The Arkansas station has developed rice field mosquito control that is between 99 and 100 percent perfect, if the following essential steps in the method are carefully watched: (1) Use of the proper insecticide; (2) thorough penetration of the rice foliage by the insecticide; and (3) proper timing of the application.

The land planted to rice in Arkansas increased from 191,000 acres in 1940 to 405,000 acres in 1949. Rice field mosquitoes have increased very significantly during this period of acreage increase. They have

become a major pest over large areas in the State. During periods of heavy mosquito infestation, one frequently finds rice fields with an average of 50 larvae to the square foot, and occasionally even more.

Failure of dusts or sprays to penetrate the heavy vegetative cover formed by the growing rice, frequently present at the time applications for mosquito control must be made, was at least partially responsible for some of the early mosquito control failures. This problem was solved by developing pellets or granules which when applied in a manner similar to dusting would penetrate the vegetative cover but, after coming in contact with water, would break up and release the insecticide. Of the various available materials tested, pellets made of bentonite and insecticide showed the greatest promise.

To make the pellets, the insecticide was first thoroughly mixed with the bentonite. Water was then added until the mixture became a medium-stiff mud that was spread out in a thin layer on a canvas and placed on a screen. Rubbing the canvas with a trowel forced the mud through the screen. When the particles had thoroughly dried, most of them became well-formed pellets containing the right amount of insecticide.

Dieldrin applied in pellet form proved more toxic than the other insecticides tested. It retained its toxicity better when exposed to weather in the field. Good results were also obtained with DDT. Because of the weight and nondrifting qualities of the insecticide pellets, they may be applied from greater heights and with more wind blowing than dust or sprays. These advantages, together with the small dosage required (2 pounds of pellets containing 5 percent dieldrin or DDT to the acre), make practical the use in applying them of smaller, less expensive airplanes, that can operate more hours during the day, and thus lower the cost of mosquito control. Applying the insecticide on the second day after the second watering was begun, gave best results.

Developed primarily for Arkansas conditions, where rice is grown on large acreages, this dusting method would probably be useful in other places where rice is grown; also in some other mosquito-breeding areas covered with dense vegetation. The method would be useful in protecting troops as well as civilians and livestock from mosquito attacks.

Better fly control in dairy barns

The New York (Cornell) station reports a new and better method of house fly control in dairy barns. Entomologists engaged in the research observed that flies were partial to narrow objects as resting places. The flies favored a screen surface to one of wood, glass, or metal, particularly surfaces of screen strips placed near the ceiling. To supply such surfaces, narrow rolls of screen wire three-fourths inch wide and 100 feet long were dipped in the insecticide, and then allowed to dry. After drying, these strips were unrolled, cut into sections, and fastened to the ceilings of test barns. Because of its high toxicity and nonrepellent quality, dieldrin produced the best results. Screening treated with it killed house flies in 5 seconds in laboratory tests. Treated strips gave good control for 16 weeks or more in barns in New York State.

A further advantage of treated strips of screen is that flies will cling to them long enough to get a fatal dose of poison. With other surfaces they tend to drop off before sufficient exposure to the insecti-

cide. The new strip method removes the danger of milk contamination since the screening may be dipped and dried outside the barn, and fastened to the ceiling out of reach of livestock.

Mist concentrate sprays profitable on fruit

One of the costliest operations in commercial fruit growing has been that of applying spray schedules that would reduce both insect and disease damage. Research at the Pennsylvania station, in cooperation with commercial growers, extension specialists, and chemical spray manufacturers has developed mist concentrate sprays that have reduced spraying costs. In concentrate spraying, air-blast sprayers are used and larger quantities of chemicals are put in a smaller amount of water. This mixture is then atomized through nozzles with fine openings into an air current that drives it into the trees. By this system air is used as a substitute for most of the water required formerly. Instead of applying 15 to 20 gallons of coarse spray to an apple tree, a grower blows 3 to 4 gallons of fog-like mist into it.

Growers in southern Pennsylvania used concentrate spraying on about 500 acres of fruit in 1949 and on more than 1,000 acres of apples, peaches, and cherries in 1950. No wasteful drip was found underneath trees sprayed the new way. Spray chemicals applied with air-blast sprayers stay on the trees. Actually, growers used 40 percent less spray material than was necessary by the old method. They hauled only 20 percent as much water and used only 30 percent as much labor. Their savings ranged from \$50 to \$60 per acre. There are over 30,000 acres in the area in blocks large enough to be suitable for concentrate spraying.

Ant control reduces fruit pest

The California station reports that killing ants on orange trees increased the amount of foliage and fruit as well as the size of the fruit. The ants attack the parasites of insects that feed on orange trees. Killing the ants allowed the natural insect enemies to establish biological control of plant-feeding insects. Naturally the removal of these pests improved the health and vigor of the tree, which resulted in an increase in the number and size of the oranges.

The experiments got under way by making comparisons between ant-free and ant-infested trees in a number of groves. The groves had been untreated for periods of several years and natural enemies had been given a chance to establish themselves without interference from applications of insecticides. For example, one of two orange trees was kept ant-free for 2 years. At the start pest populations on the two trees were very similar. The condition of the two trees was virtually identical. Since then the ant-free tree has become more and more free of pests until now it is exceptionally clean and very vigorous. The ant-infested tree, although never too heavily populated by any given pest at any one time, has suffered cumulative damage from increasing numbers of citrus mealybugs, red scale, soft-brown scale, black scale, citrus red mites, and aphids until real differences between it and the ant-free tree were evident after 2 years. The ant-infested tree now has considerably less foliage than the ant-free tree and 70 percent as much fruit. The fruit is smaller, averaging 344 per box compared with larger sized oranges (200 per box) on the ant-free tree. Noticeable differences between the insect infestations on the two trees

did not occur for nearly 9 months, but gradually they became more and more apparent.

Research on the control of green apple aphids at the Maine station has shown that when these aphids are present they are frequently accompanied by large, black ants, which are antagonistic to the natural enemies of the aphids. Three isolated trees, severely infested with the green apple aphids, were banded with cotton batting saturated with chlordane dust. The ants were unable to pass the barrier on the trunks of the trees, and the aphid infestation soon subsided.

Insecticides make bigger cotton crop

Over a 4-year period, 303 test plots of recommended insecticide treatments resulted in an average yield of 1,862 pounds of seed cotton per acre as compared with 1,094 pounds on the untreated areas. These averages were established in cotton insect control research at the Alabama station. They show that the cotton crop averaged 768 pounds more seed cotton per acre as a result of insecticide treatment. Success was not obtained with any one insecticide but with insecticides used in various combinations. The Alabama station also found that over a 2-year period areas sprayed with an insecticide yielded an average of 1,567 pounds of seed cotton per acre as compared with 1,444 pounds on dusted areas, and with only 463 pounds of seed cotton per acre on the untreated cotton. High-clearance, self-propelled sprayers were used effectively in 1950 for the first time.

Experiments conducted at the Texas station indicated that several insecticides are effective for the control of cotton insects in the State. The average net gain on a number of experimental plots ranged from 672 to 1,223 pounds of seed cotton per acre as a result of controlling the boll weevil and bollworm with about 8 applications of insecticides. These increases in yield gave net profits ranging from \$72 to \$133 per acre. On the average each application increased the yield of seed cotton approximately 100 pounds and returned a net profit of \$11 per acre-application.

Insecticide treatments boost hay yield

The spittlebug is fast becoming a serious economic insect pest, attacking a variety of crops ranging from strawberries to red clover and alfalfa. In seeking ways to control spittlebugs attacking meadow crops, the Ohio station found that BHC (benzene hexachloride) and toxaphene gave best results.

Spittlebug attack is indicated by frothy, saliva-like masses of spittle on the stems and leaves of plants, especially in the leaf axils. Inside these frothy masses are small greenish-yellow nymphs which suck the plant juices, passing most of the liquids through their digestive systems to produce the frothy masses. When the young spittlebugs complete their development, usually in June, they become mottled-brown insects which resemble large leafhoppers. They are common and often are seen resting on trees and plants.

The Ohio station has shown that low-volume spray equipment will give good spittlebug control when the plants are small but higher volumes are necessary after plants attain a fair growth. Ground sprayers were more efficient than aircraft dusters and sprayers but the latter gave commercially satisfactory results. It is possible to use this spray method of controlling the insect without danger of

insecticidal residues on the finished crops. Methods developed by the Ohio station increased the average hay yields from 25 to 30 percent on 97,000 acres in 84 Ohio counties. The value of such yield increases would exceed one-half million dollars. The station also discovered that some varietal resistance of the spittlebug may be present in red clover.

Insecticides boost tobacco yields

The Florida station has proved that insecticide treatments will increase the yield of tobacco infested with budworms and hornworms. Six insecticides were found to be effective. The untreated plots yielded 534 pounds of tobacco per acre, whereas the insecticide-treated plots yielded from 842 to 1,415 pounds. It is now possible to produce good yields of tobacco of high quality with only four or five applications of insecticide.

Better onion maggot control

The onion maggot is a destructive insect in New York State and sporadically causes serious losses. To control this insect the New York (Cornell) station devised a rotary duster mounted on a three-row seeder which was used to blow combined insecticide-fungicide dusts directly into the furrow at time of seeding. On one farm where untreated onions were over 80 percent destroyed, insecticidal dusts reduced maggot damage to 3 percent in the treated rows. An advantage of this dusting treatment was that one application at planting time was sufficient to give protection during the entire growing season, thus combining increased efficiency with economy.

More worm-free sweet corn

An increase of over 750 dozen worm-free ears of sweet corn per acre is reported by the Alabama station through control of the corn earworm with three properly timed spray applications containing DDT and mineral oil emulsion. The sprays were applied in the region of the ear at 3-day intervals, beginning when one-half of the plants were showing silk.

In South Carolina the station entomologists found that four to five spray applications to sweet corn, the first two made prior to silking, gave 90 to 99 percent freedom from corn earworm damage. The pre-silking sprays were found to be very important in this area because corn treated after silking had less than 30 percent worm-free ears.

Insecticide saves seed crop

Research at the Idaho station showed that BHC (benzene hexachloride) dust is an effective control for the cabbage seedpot weevil which has been a serious pest on rape and turnip seed grown in Nez Perce, Lewis, and Clearwater Counties since 1946. Estimates of seed damage have ranged from 20 to 50 percent of the total crop in many fields. In fact, the pest had become so bad that the development of an economical control for it on rape and turnip seed crops was necessary to prevent elimination of these crops in the area. Since approximately 90 percent of all the rape seed produced in the United States is grown in this area, control of the weevil is vitally important.

Even with extremely heavy populations of weevils the research showed that seed losses can be reduced to a minimum. For example, during 1950 in a heavily infested field which had a population of 500 weevils per sweep of the collecting net, the seed loss following control

was only slightly over 18 percent. If no control had been applied, the field would have been a complete loss.

Grasshopper damage cut with insecticides

Grasshopper control experiments in alfalfa fields conducted by the South Dakota station during the past 5 years have shown that when 95 to 100 percent control was obtained with aldrin, toxaphene, and chlordane in large fields of alfalfa (80 acres or more), reinfestation of such fields did not occur the following year, and the beneficial effect of the control extended over several years. On the other hand, when 95 to 100 percent control of grasshoppers was obtained in small fields of alfalfa such fields, unless well isolated or surrounded by fields free from grasshoppers, often became repopulated with grasshoppers the following year and needed control again. Alfalfa fields in which grasshopper control was less than 95-percent efficient, usually required spraying the following year.

In detailed studies of the feeding habits and food preferences of range-infesting grasshoppers the Montana station learned that 15 of the 52 species studied were strictly grassfeeders and 5 of these were found only where their preferred grass was growing. Nine fed solely on herbs other than grass. The knowledge that these grasshoppers are selective feeders during at least part of their life cycle has a direct bearing on control recommendations on the range. Many grasshoppers were found to be general feeders. Grasshopper utilization studies were also made on sprayed and unsprayed areas. With an average population of approximately seven grasshoppers per square yard in the unsprayed areas, the decline in weight of grass as a result of grasshopper utilization was approximately 250 pounds per acre. This would result in decreasing the carrying capacity of the range approximately 50 percent. As a result of this research, the importance of grasshoppers in range management practices is clearly defined.

SOIL SCIENCE AND PLANT NUTRITION

Many significant contributions to increased crop production have stemmed directly from research findings in soil science and plant nutrition. A good example of recent research progress along these lines is that dealing with phosphorus. The current shortage of the usual available fertilizer sources of this necessary plant nutrient places much greater emphasis on its proper use.

In order to offset, insofar as possible, any reduction in average yields of food and fiber crops that might result from the short supply⁴ of phosphatic fertilizers in 1952, it is essential that maximum use be made of present research information on all soil and plant factors affecting phosphorus utilization.

The relation of phosphorus fertilizers to food and fiber production was recently brought out by four regional surveys conducted jointly by the United States Department of Agriculture and the State experiment stations. The report for the 12 North Central States, for example, shows that corn production could be increased by 120 million bushels and wheat by 30 million bushels if farmers doubled their present average rate of application of 8 pounds of phosphoric acid

⁴ The present short supply of sulfur is limiting the production of sulfuric acid which is used in converting raw rock phosphate into superphosphate fertilizer.

(P_2O_5) equivalent per acre. This would be equivalent to cropping 3 million additional acres of land to corn and more than 2 million acres to wheat. The use of 26 pounds of P_2O_5 per acre on crops grown for hay, instead of the present rate of 13 pounds, would be equivalent to adding more than 1 million acres of hay in this region. To get the additional phosphatic materials necessary to produce these increases would require an additional 600,000 tons of P_2O_5 . Increased supplies of available phosphates will not be obtainable, however, for agricultural production in 1952.

Instead of depending on increased amounts of phosphate fertilizers to obtain greater agricultural production in the immediate future, it will be necessary to make the best possible use of available supplies as well as of present knowledge relating to disease, insect, and weed control measures, and soil- and crop-management practice. Wherever the best farm practices are carried out, it may be possible to increase both yields and total production of food and fiber crops in 1952 without an expansion in acreage. There are few remaining acres that can be considered to be well adapted to such crops as cotton, tobacco, and corn. It is highly important, therefore, that increased per acre yields and efficiency of production be emphasized, rather than any further expansion of crops to land where they are not adapted.

Response to Phosphorus Fertilization

Experiments with different fertilizer materials applied to the surface of rough, unproductive pastures, conducted over a 30-year period by the Storrs station (Connecticut) show that phosphorus alone (as superphosphate) increased the total production of herbage by 67 percent. Superphosphate and lime gave an increase of 107 percent, and when potassium was applied in addition, the increase was 126 percent. An average increase of 171 percent was obtained where nitrogen was applied in addition to lime, phosphorus, and potassium. On the large acreages of rough, steep land in the Northeast, one of the most practical means of cheaply and quickly improving pastures is through the surface application of fertilizers.

Many soils in the Midwest are low in available phosphorus. Frequently such soils require high initial applications of phosphate fertilizer in order to obtain maximum yields. Research at the Iowa station was started in 1947 to determine the rate of application needed for maximum yields and profitable returns on the phosphorus-deficient Ida soil. Applications of 0, 60, 120, and 240 pounds of P_2O_5 per acre were made on oat-legume seedings. Yields of second-year alfalfa were 0.5, 1.8, 2.8, and 4 tons per acre, respectively, for the different rates of phosphorus. Corresponding yields of corn, following 2 years of meadow, were 14, 23, 36, and 57 bushels per acre. In other experiments, different rates of superphosphate were applied in 1946 to oats in a 5-year rotation on Webster soil of very low available phosphorus content. Five seasons later the 240-pound rate of P_2O_5 produced 87 bushels of corn per acre compared with 69 bushels for the check treatment. The 4-year average yield of alfalfa hay was 5.6 tons per acre for 240 pounds of P_2O_5 , as against 3 tons for 60 pounds of P_2O_5 , and 2.4 tons for the no-phosphorus treatment.

Experiments such as these show that large amounts of phosphate fertilizer are needed on midwestern soils low in available phosphorus,

and also that there is an appreciable residual effect on succeeding crops in the rotation.

A mixture of Ladino clover, Alta fescue, and perennial ryegrass produced marked responses to fertilizer on a phosphorus-deficient soil at the New Mexico station. All plots were irrigated. The no-fertilizer plots produced 3.4 tons of dry forage per acre, whereas those receiving 50 pounds of P_2O_5 per acre produced 6.27 tons. When 100 pounds of P_2O_5 was applied, 7.92 tons was produced, an increase of 133 percent; and when 100 pounds of nitrogen was used in addition, the yield was 8.22 tons per acre, an increase of 142 percent. In actual farm practice, irrigated pastures of similar grass mixtures have produced as much as 1,300 pounds of beef per acre, and it is believed that by combining all of the improved fertilizer and management practices, beef yields of 1,500 to 2,000 pounds per acre could be attained.

Phosphorus experiments conducted by the Kansas station on farms in 11 counties of central Kansas showed that response to applied phosphorus was generally inversely related to the amount present in the soil. Yield increases varied from 0 to 16.9 bushels per acre on soils varying in available phosphorus from 200 pounds down to 18 pounds per acre. In 8 of the tests where 30 pounds of P_2O_5 was applied with the seed in the fall, the yield of wheat was increased by 4.5 bushels, and where a further treatment of 24 pounds of nitrogen was applied in the spring the increase was 7.9 bushels per acre. This latter treatment resulted in an average profit of \$10.85 per acre. In Chase County on soil containing 26 pounds of available phosphorus per acre, the same method and rate of fertilization increased yields by 17.5 bushels and gave a profit of \$30.05 per acre. In other experiments, fertilization with superphosphate increased red clover hay yields by an average of 7.6 percent and alfalfa yields by 10.7 percent. Phosphate carriers less soluble than superphosphate gave much smaller increases.

Experiments by the Iowa station on Grundy soil showed that rock phosphate at the rate of 240 pounds of P_2O_5 per acre gave no response when the soil was limed to pH 6, whereas on the Edina soil at pH 5.6 rock phosphate plowed under at the same rate increased corn yields by 10 bushels per acre. Superphosphate applied in the hill at 10 or 20 pounds of P_2O_5 per acre gave a similar increase in corn yields. The response of corn to superphosphate on the Grundy and Edina soils was unaffected by the rate of liming.

Rock phosphate ground to a fineness of between 100 and 200 mesh was just as effective in sweetclover production at the Oklahoma station as that ground finer than 200 mesh. The downward movement of rock phosphate particles was also studied. Particles smaller than 100 mesh, but larger than 200, did not move downward in a medium-fine sand when leached with 60 inches of water. Particles finer than 200 mesh did move downward in this medium, but did not move appreciably in a very fine sand.

Availability of Phosphorus to Plants

The solubility of phosphorus in rock phosphate was determined at the Wisconsin station over the pH range 4 to 7, using buffered acetic acid. Between pH 4 and pH 5.5, the phosphorus of rock phosphate went into solution quite rapidly, although between the pH values of

6.5 and 7, the solubility was too low to meet the needs of most crops. Because of the high pH requirement of alfalfa, rock phosphate is not readily available under Wisconsin conditions, and is not recommended for rotations that include alfalfa. It is satisfactory, however, in clover rotations where a soil pH of 5.5 to 6 may be tolerated.

It has long been known that many soils do not respond well to rock phosphate. Results of studies on the weathering of this material carried out at the Missouri station indicate that saturated clays were no more effective in weathering rock phosphate than distilled water, whereas unsaturated clays weathered rock phosphate as rapidly as did dilute hydrochloric acid. The conclusion reached was that if rock phosphate is to be used to best advantage, soil colloids should be less than 80 percent saturated with bases.

At the Arizona station, a relationship was found between the amount of phosphorus soluble in water saturated with carbon dioxide, and the availability of soil phosphorus to plants. Soluble phosphorus added to calcareous soils was fixed only to a slight extent against water extraction. Field experiments (coop. USDA) with radiophosphorus indicated that superphosphate, ammonium phosphate, and liquid phosphoric acid placed in a band were about equally available to alfalfa and cotton. Alpha-tricalcium phosphate was less available, and calcium metaphosphate was intermediate. This and other research at the Arizona station shows that soluble phosphorus added to calcareous soils may remain available for plant use over a long period of time. The fact that calcium metaphosphate has been found to be a satisfactory substitute for superphosphate on calcareous soils may be very important during the present period of sulfur shortage.

The Ohio station (coop. USDA) also found calcium metaphosphate to be a satisfactory fertilizer material, in comparison with superphosphate, on five different soils having pH values ranging from 5.5 to 7.5. The yield of corn increased with soil pH, but the two sources of phosphorus gave about the same yield response as a given pH level. Calcium metaphosphate could now be used, at least in part, to replace superphosphate on many Ohio soils.

Because many New England soils fix large amounts of phosphorus in forms unavailable to plants, the Vermont station began a study of the process of phosphate fixation in 1941. This research confirmed previous findings that the iron and aluminum in acid podzolized soils were largely responsible for phosphorus fixation. The reaction was essentially a substitution of the phosphate ion for the hydroxyl ion in the hydrated iron and aluminum oxides. In many experiments, only about one-third of the average application of phosphate remained available for plant growth. It was learned from this research that such practical measures as using superphosphate on manure, and the banding in the soil of granulated phosphatic fertilizers were quite helpful in reducing fixation and insuring longer availability of phosphorus. Maintaining soil organic matter and liming were also found to reduce the fixation of applied phosphorus. In Vermont, liming is generally recommended prior to the application of phosphate-bearing fertilizers. Superphosphate is not recommended as a broadcast application on plowed land where it becomes thoroughly mixed with the soil. Much valuable phosphate fertilizer is saved every year when such practical measures as these are followed.

Research conducted by the Iowa station has confirmed the known importance of the role played by organic matter in supplying phosphorus to growing crops, especially during periods of favorable temperature and moisture conditions. Recent findings on the separation, identification, and determination of organic phosphorus compounds (chiefly inositol phosphates, and nucleic acid-like materials) should greatly add to our understanding of the decomposition processes, as well as the nature of both the resistant and nonresistant fractions.

For the first time in soils research, the technique of anion exchange chromatography⁵ was used by the Iowa scientists (coop. USDA) in separating the organic material inositol-hexaphosphate, known as phytin, into several fractions. In other studies, it was found that micro-organisms can synthesize phytin. Inorganic radiophosphorus was incubated with moist soil, and it was later demonstrated that the soil inositol-hexaphosphate fraction is radioactive. Since the micro-organisms themselves feed on inorganic phosphorus compounds, the rate at which radiophosphorus was synthesized into organic phosphorus was found to be a very satisfactory and reliable index of the availability of different phosphate materials.

The influence of varying amounts of radioactive phosphorus on the activity of soil micro-organisms was also investigated (coop. USDA). In sand cultures treated with dextrose, urea, and mineral salts, and inoculated with a soil extract, the presence of 5 millicuries of radiophosphorus (P^{32}) in 10 milligrams of phosphorus as orthophosphate per kilogram of sand, the rate of carbon dioxide production was temporarily reduced and the microflora was considerably changed. No effect was found when smaller amounts of radioactive material were used. It was concluded, therefore, that the level of P^{32} commonly used in experiments is low enough to be without any significant microbiological effect.

The Colorado station (coop. USDA and TVA) continued studies on the comparison of phosphorus availability of different materials. On Las Animas soil, sugar beets yielded as well when fertilized with ammoniated superphosphates (maximum of 3.3 percent ammonia) as with concentrated superphosphate. The availability of calcium metaphosphate to the plant increased as the particle size of the fertilizer decreased from 10 to 40 to 100 mesh. The 100-mesh material was not as available as concentrated superphosphate early in the season, but was equally available by the end of the season. Phosphorus added as liquid phosphoric acid or as 11-48-0 in irrigation water, was equally available from the two sources. Two of the new dicalcium nitraphosphates were found to be of the same availability to alfalfa as concentrated superphosphate.

Ammoniated and ordinary superphosphates were compared at the Virginia station (coop. USDA) by absorption of radioactive phosphorus. No significant difference in yield or uptake of P^{32} by corn resulted from ammoniation. In other experiments, liming was found to increase the availability of applied phosphates as measured by P^{32} uptake of alfalfa. In comparison with superphosphate the phosphorus in dicalcium nitraphosphate (11-33-0, 15 percent water-soluble

⁵ Chromatography is a physical adsorption technique used in separating closely related complex organic compounds that cannot otherwise be separated.

P_2O_5) had an availability of 107 percent, dicalcium nitraphosphate (17-22-0, 2 percent water-soluble P_2O_5) 88 percent, and fused tricalcium phosphate (40 mesh) 57 percent as measured by the absorption of P^{32} by oats. More phosphorus was taken up by oat plants at intermediate pH levels than at pH 4.8 or pH 8.0. The Virginia scientists emphasized that increased efficiency of absorption of phosphorus by plants is essential to prolong the life of our natural deposits. They estimate that the 10.5 million dollars spent annually for phosphate fertilizers by Virginia farmers could be reduced at least 1 million dollars by a 10-percent increase in efficiency of applied phosphate materials.

The Georgia station (coop. Mississippi, South Carolina, Alabama, and USDA) studied the availability of different particle sizes of calcium metaphosphate and fused tricalcium phosphate on two different soils in comparison with 20-percent superphosphate. The uptake of P^{32} by alfalfa from all sources averaged 17.2 percent for a soil containing 50 pounds of available P_2O_5 per acre, and 45.5 for a soil containing only a trace of phosphorus. Five weeks after application, the superphosphate had been absorbed to the highest extent by alfalfa, but at 10 weeks the phosphorus was equally well absorbed by alfalfa from all particle sizes and the three sources. There were no significant differences in yields.

FRUIT PRODUCTION RESEARCH

Probably no other crop is affected so directly by location as are the fruits. A wide range of soil, weather, and other natural conditions present growers with definite area problems that usually determine the program of experiment station research in fruits. Economic factors such as labor supply, distance from market, and similar factors already discussed in the section on agricultural marketing, also enter into the planning. For the most part there is a close connection between the dominant fruit industry of the State and the character of the research. However, the techniques employed do not vary so greatly as the crops. Well-trained biochemists, physiologists, and geneticists are found on the various pomological staffs. From the efforts of such men, working in close cooperation with growers and extension horticulturists, have come many outstanding developments in recent years.

The examples here discussed are sufficient to indicate the type of research pomologists and their coworkers at the State experiment stations are doing toward the development of more efficient and more economical practices to assure abundant supplies of fruit for the Nation and to provide growers with an incentive to produce.

Nutrition of fruit trees

Much interest has been displayed in the more effective nutrition of fruit trees. It is a far cry from the days when nitrogen was considered the only nutrient that could be applied profitably to orchards. Certain stations in the McIntosh apple region—notably New York (Cornell) and Massachusetts—have found that it is possible to oversupply nitrogen to the fruit tree to the detriment of good color and consequent marketability. Research at the New York (Cornell) station indicated that better control of the nitrogen supply to the Mc-

Intosh apple could be obtained by spraying nutrient solutions on the foliage than by soil applications. Urea sprays gave a rapid temporary nitrogen effect which was greater than was obtained from soil applications of a comparable amount of nitrogen. The investigation showed that the lower surface of the apple leaf absorbs much more urea than does the upper surface during the first few days after the spray is put on. Detergents such as soaps increased the rate of absorption materially and young leaves absorbed urea more efficiently than did older foliage. As a result of the Cornell research, more than a fourth of the New York apple growers are now using urea sprays to fertilize trees. By properly timing urea sprays also it has been possible to control the effects of nitrogen on the yield and color of the fruit.

The Massachusetts station found a negative correlation between nitrogen content in the leaf and the color of the fruit and a positive correlation between leaf potassium and red coloration of fruit. These observations led the station to suggest the need of a proper balance between nitrogen and potassium in the fertilizer supplied to the apple tree.

The Ohio station used leaf analyses to explore the minor element needs of apple and peach trees in several growers' orchards. It found that deficiencies of potassium, magnesium, and boron in the apple and of potassium and magnesium in the peach are sufficiently frequent to warrant their application in proper amounts for the benefit of yield and quality.

By the use of radioactive phosphorous compounds, the New Hampshire station established that phosphorus can be absorbed into the foliage of the apple tree in considerable quantity from foliar sprays and that the phosphorus entering the leaves is translocated to various other parts of the plant. The station suggests that growers may be able to conserve large amounts of phosphorous fertilizers by spraying solutions of phosphatic materials on the foliage rather than applying the phosphorus to the soil. A considerable amount of the phosphorus applied to the soil fails to benefit the tree because it is converted to insoluble forms that are not readily available.

The use of leaf analyses as a means of determining the nutrient status of fruit trees in commercial areas was explored by the California station at Davis. Leaf readings revealed potassium deficiencies in unsuspected areas and yield records confirmed the value of earlier treatments on established plots. The correction of potassium deficiency was best obtained by large single applications of potassium materials which remained available over a period of years. In 1950 almond yields in a certain orchard showed a 54-percent increase where potassium was applied in 1947.

The need of balanced nutrition of the fruit tree was indicated in studies at the Delaware station. Apple trees fertilized with a 10-10-10 (NPK) mixture made 14 percent more growth than those supplied nitrate alone. The use of a 10-6-4 material gave no better results than straight nitrate. The Delaware station suggests that inadequate nutrition may be reflected in low yields even when the foliage itself does not show nutrient deficiencies.

The value of balanced nutrition was shown also by the Michigan station in experiments with Montmorency cherries. The station found

that any change from the optimum, either for a single element or the total concentration, brought about considerable distortion in balance and a reduction in growth.

Mulching vs. sod culture

Hay mulches were shown by the Missouri station to be superior to sod culture in the management of apple orchards. Total nitrogen, total exchange capacity, available phosphorus, and soil moisture were higher under hay mulch than under sod. Similarly favorable results with hay mulches were reported by the New Hampshire and Maine stations. In New Hampshire, Northern Spy apple trees mulched with hay since 1941, with no supplemental fertilizer, showed a doubled increase in yield in the period 1948-50 over unmulched trees in sod and supplied with nitrogen.

Blossom thinning with chemical sprays

Further research on the control of yields with blossom-thinning sprays were reported. The purpose is to obtain larger fruits and encourage annual bearing in those varieties that tend to fruit abundantly only once in 2 years. Although these techniques have been studied by various stations and the Department for several years, there have been some recent interesting findings.

The Missouri station reported that biennially bearing Golden Delicious apple trees, thinned heavily in 1949 by the use of naphthaleneacetic acid sprays, produced abundant flowers and set a heavy crop of fruit in 1950. The hormone treatments were applied 10 days after pollination occurred. Sprays applied 4, 6, and 8 weeks after pollination were unsuccessful, showing that timing is an important factor in the successful use of the hormone sprays.

In Pennsylvania, 15 acres of Rome, McIntosh, and Stayman apples were used by the station workers in tests of concentrations and timing of naphthaleneacetic sprays for thinning fruit. Wide variations were recorded in results of the sprays on individual trees and even on separate limbs of a single tree—all receiving identical treatments. The most effective thinning was obtained by spraying 15 to 20 days after full bloom at a concentration of 20 to 25 parts per million. No burning or harmful curling of leaves was noted under these conditions.

Results of West Virginia station experiments in thinning apple blooms with chemicals indicated that full-bloom sprays of DN No. 1, dinitroorthocyclohexylphenol at a narrow range of concentrations, one-half to three-fourths pound per 100 gallons of water, were very satisfactory. Poor results obtained with delayed naphthaleneacetic acid sprays led to the recommendation that in West Virginia this material be applied at petal fall and no later.

Unfavorable results reported by the Idaho station with the use of the so-called "speed sprayers" for applying blossom-thinning sprays to Jonathan apple trees were attributed to the fact that the quantity of material applied per tree was too small. Only 7 gallons per tree were applied by speed sprayers as compared with approximately 20 gallons when a hand outfit was used.

Good results were obtained by the Massachusetts station with naphthaleneacetic acid blossom-thinning sprays applied to apple trees at the time of calyx fall. Repeat applications appeared to have little value, and calyx applications thinned blooms more successfully than did the same treatment 2 weeks later.

Controlling preharvest dropping of apples

Because of the losses incurred from dropped fruit, growers have been interested in experiments on the effect of various chemicals on the preharvest dropping of apples and other fruits. Research along these lines is under way both in the Department and at various State experiment stations. In 1950 the West Virginia station made studies on the usefulness of 2,4,5-trichlorophenoxypropionic acid (2,4,5-TP) as a preventive for premature dropping of Williams, McIntosh, Red Rome, Red Delicious, Gallia, and York apples. On Williams, the spray not only eliminated drop but resulted in early coloring and ripening. Good results on drop control were obtained in the other varieties. Naphthaleneacetic acid, used as a control, was not so effective as the 2,4,5-TP spray. This new material was also tried by Massachusetts station researchers who reported that low concentrations of 2,4,5-TP applied to apples prior to harvest hastened maturity and red color development.

Electrostatic dusting appliance

A highly interesting and promising new development in dusting fruit and other plants was reported by the Michigan station. The problem of getting dusts to adhere has long perplexed the fruit grower. A high electric charge as the dust particles leave the nozzle of the duster gave as much as 5 to 10 times better coverage than was obtained under ordinary procedures. In theory, the plant sets up an opposite electrical charge which acts like a magnet in holding the dust particles to the leaf surfaces, where they can successfully overcome insect and disease attacks. Credit goes to the agricultural engineers for devising the equipment necessary for this type of dusting, which they believe can be added to a modern 4-row duster at a cost of not more than \$300.

VEGETABLE CROP RESEARCH

Home vegetable gardens play an important part in meeting food needs, especially during periods of all-out industrial production. A Nation-wide survey in 1951 showed that an estimated 17,000,000 families had home gardens in the United States and that about 46 percent of all families preserved fruit and vegetables from their own gardens or from produce bought at markets and roadside stands. State experiment stations serve these home gardeners as well as the commercial vegetable producers in the research carried on in vegetable breeding and in finding improved cultural methods. Although new and better varieties of vegetables frequently are introduced to the public through the popular seed catalogs, the scientific work necessary to make the new varieties possible is often done by the experiment stations and the Department of Agriculture, at times in close cooperation with the seed growers. The several examples of research here presented supplement the examples of research in vegetable marketing mentioned in the section of this report on agricultural marketing.

Breeding

New lima and other beans

The Oklahoma station has recently announced the Bixby lima bean. Its introduction culminates painstaking work carried on in Oklahoma since 1937. Bixby originated in a cross of Fordhook and Henderson's

Bush made at the Maryland station in 1936. The new variety is considered particularly suitable in the southern and southwestern parts of the United States. It has considerable resistance to heat and drought and has shown nematode resistance in cooperative trials with the Department.

To be added to the long list of new varieties of vegetables that have come from the New Hampshire station is the horticultural shell bean named Shelleasy that will mature earlier than its parent Flash. The pods of this newcomer are attractively mottled with red.

Broccoli, celery, cucumbers, melons

Broccoli is increasing in favor as a table vegetable and the State stations conducting research on this vegetable are directing their effort to the development of superior varieties. Two new strains have been developed at the Massachusetts station—Waltham 11 as a spring crop and Waltham 29 for harvest in the fall. From as far south as Maryland, growers have reported favorably on Waltham 29.

The Texas station has recently announced Texas 107 as a new variety of green sprouting broccoli. Its outstanding characteristic is its high production of side sprouts. In comparison with available commercial varieties, it is reported to be usually superior in earliness, evenness of maturity, and quality of head.

Recognizing the increasing market demand for green celery, the Michigan station has now developed a light-green hybrid that is highly resistant to *Fusarium* yellows, is of good quality, handles well, and is suitable for growing in Michigan either as a summer- or autumn-maturity variety. The variety has been named Michigan State Green-Gold; and was especially bred for Michigan climatic conditions. It grows to maturity in 90 to 100 days as a summer crop and in 100 to 110 days when managed for fall harvest.

The New York (Cornell) station has now released a slicing cucumber named Niagara. Its outstanding qualities are the vigor of its vines and its resistance to mosaic. The fruits are of good length, smooth, almost without taper, round-ended, and well-colored.

Rio-Sweet is the name given to a new cantaloup, or muskmelon, announced by the Texas station. It was developed from a cross between a wild so-called "smell melon" and Hales Best. It is resistant to, but not immune from, downy mildew. The rind ground color is green to yellowish green, but otherwise it fits well into the accepted commercial standards. Its exceptional good flavor and texture are noteworthy.

New southern peas

The Southern Pea (edible cowpea) is becoming increasingly popular for both canning and freezing, particularly in the Southern States. The Mississippi station has announced the Dixielee as a good yielder under a wide range of soil and climatic conditions. It is adapted to a wider range of soil types and conditions than the Blackeye, Purple Hull, or Crowder. Its yield records exceeded or compared favorably with the varieties mentioned. It did well when grown over a long planting season.

Within the past year, the Texas station has introduced a new variety of Southern Pea for table use. It has been named Purple Hull No. 49 and, according to tests in Texas, it is one of the earliest maturing varieties of high quality. The only competitor for this new variety in

the State would appear to be Jackson Purple Hull which it exceeds in both ease of shelling and appearance of the processed product.

Peppers and squash

In an effort to develop a superior variety of pungent peppers, the South Carolina station has made available Cayenne strain No. 4569a. The total production of this new strain in 1950 was 1,949,802 pounds of dried pepper valued at over $\frac{1}{2}$ million dollars. However, attempts to improve on this new strain will continue.

The New York State station has just introduced a new type of Boston Marrow squash that offers distinct advantages both to the processor and the grower. The squash averages 10 to 20 pounds and has an orange-red skin and flesh. The fruits are uniform and smooth so that soil is easily removed, and they mature well before the frosts of late September and October. The indications are that this variety will give both high yields and quality harvests.

New sweet corn varieties

In the past year, several new sweet corn varieties developed by experiment stations have been introduced or have received noteworthy recognition. Hoosier Gold, a new yellow sweet corn hybrid of excellent quality, was developed at the Indiana station (coop. USDA). It is an early to early-midseason hybrid, usually 3 to 5 days earlier than Golden Cross Bantam.

In the "All-America Vegetable for 1951" trials, Iochief, developed by the Iowa station, was awarded a gold medal—the first one ever received by a sweet corn variety in the 20-year existence of the competition sponsored by the various seedsmen's associations in the United States.

The Massachusetts station has announced three new sweet corn varieties—Pilgrim, Golden Jewel, and Gold Mine. Approximately 30 tons of seed of these hybrids were produced in 1950 for sale in 1951.

Further north where early maturity of sweet corn is of great importance, the New Hampshire station has introduced the new, extremely early, yellow sweet corn variety, named Cocheco. The stalks grow to about 3 to $3\frac{1}{2}$ feet and bear small, attractive, yellow ears. It is an open-pollinated corn, noteworthy because of its earliness in more northern regions.

Tomatoes

Because of its popularity and the many ways it can be prepared as a food, research on the tomato has received much attention at the State experiment stations. Among the objectives sought in this research have been improved quality, pest resistance, and shipping and handling durability.

The Illinois station has developed the Urbana tomato with smooth, red, globe-shaped fruit and a rich scarlet-red flesh. The plant is compact and bushy, spreading about 36 inches. It is reported to be free from excess growth even in nitrogen-rich soils. It is recommended by its sponsors for canning, as a good shipper, and well suited for rich garden soils.

The latest tomato variety announced by the New Jersey station is Queens, seeds of which will be generally available in 1952. The variety came out of a cross between Valiant and Rutgers. It bears smooth, globe-shaped fruit that resist cracking. Queens was bred

particularly for early market. It ripens a week to 10 days earlier than Rutgers.

A tomato variety, W-R Globe, developed by the Ohio station especially for growing under glass, is continuing to gain in popularity. Production has been increased 10 percent and W-R Globe is practically the sole variety now used for greenhouse forcing in Ohio.

Golden Sphere has been announced by the Texas station as a yellow-fruited variety, highly resistant to Fusarium wilt. Tests in the Southern Tomato Exchange Program indicate that Golden Sphere equals Rutgers in earliness. The fruits weigh from 3 to 8 ounces when mature and are good for fresh eating, juice, and home canning. The climate of east Texas appears to be particularly suited for this variety.

Disease-resistant watermelons

The breeding of improved watermelon varieties proceeds as their summer popularity advances. Diseases continue, however, to be a major problem and the stations are seeking to overcome this hazard through breeding resistant varieties. The Florida station (coop. USDA) has announced the Ironsides watermelon, the product of a cross between inbred lines of Leesburg and Hawkesbury made at the U. S. Regional Vegetable Breeding Laboratory at Charleston, S. C. In 1940, it was outcrossed to an inbred line of Garrison and, after inbreeding and selection, it was sent to the Florida station in 1945. Ironsides has some of the characteristics of the California Klondike but is larger than Leesburg and Hawkesbury. Melons up to 42 pounds have been grown and 35-pound melons are not uncommon. They have stood up well under shipping tests, an indication that the rind is sufficiently tough to stand up under commercial marketing conditions.

New honors have come to the New Hampshire Midget watermelon which was reported in 1950. This small, early melon with flesh of high quality was awarded a gold medal in the 1951 competition for All-America Vegetable Selections.

Culture

Supplemental irrigation for vegetables

The Alabama station released data from irrigation studies with vegetable crops covering a period of more than 11 years. Information obtained on cost of irrigation and average values of increased yields for both supplemental irrigation and high fertilizer rates indicates that the grower may find it profitable to apply supplemental irrigation and generous applications of fertilizers.

Fertilizer response of asparagus and lima beans

The Delaware station has developed a scale of optimum rates for the fertilization of asparagus. By taking advantage of its recommendations, Delaware growers should be able to increase their income from the growing of asparagus by \$80,000 annually. The station also developed improved methods of fertilizer applications for lima beans. Best yields were obtained where 500 pounds of a 4-8-12 fertilizer were drilled before planting and an additional 250 pounds banded at planting. Equally effective was the method of broadcasting of 5 tons of poultry manure on a sassafras sandy loam before plowing, following it by banding of 500 pounds of 4-8-12 fertilizer at planting.

Improved onion culture

In an experiment on the placement of fertilizer in growing onions, the Michigan station (coop. USDA) developed a practical fertilizer-placing machine. The machine was used in trials with various rates of fertilizer applied on muck soil in different positions with respect to the seed. Yields of Michigan-grown commercial onions were increased 55 percent by the local fertilizer placement method as compared with yields of onions fertilized with the usual grain drill broadcasting equipment. Under the recommended new method, 400 pounds of fertilizer doubled the response in yields.

The New Mexico station, seeking methods of increasing the yield of onion seed, has shown that the position of the onion bulb in the soil can greatly influence the ultimate yield of seed. Onion bulbs placed in an upright position in the planting furrow gave yields 40 percent higher than bulbs planted at random in the furrow. The latter method has been standard practice among New Mexico growers. It is estimated that, at present prices, the income for farmers producing onion seed can be increased up to \$300 per acre where the bulbs are set upright in the furrow.

Mulching improves moisture supply

The Pennsylvania station demonstrated that mulched cucumbers give increased yields over cucumbers grown under clean cultivation. Mulched sweet corn, tomatoes, and broccoli gave higher yields than those receiving clean cultivation. Sawdust, leaves, straw, grass clippings, and manure mulches all caused tomato plants to give higher yields than when the plants were grown under clean cultivation. The primary cause of the higher yields for the vegetables grown with a mulch was improved moisture.

Synthetic compost for growing mushrooms

The Pennsylvania station has shown that mushroom growers in the State may save nearly 2 million dollars a year by substituting synthetic compost for horse manure in growing this crop. The formula used for the compost was compiled and tested at the Pennsylvania station. Its general use would also provide an outlet for 1/2 million tons of low-grade hay annually.

Handling, Storage, and Processing

New vegetable-drying technique

Improved methods of drying vegetables have been developed at the Louisiana station. Where vegetables are dried in dehumidified air, at temperatures lower than usually employed, an end product is obtained that, when reconstituted, will retain all the natural qualities of the fresh food. Costs of this improved method compared favorably with costs under the older methods of drying and, in addition, the kinds of vegetables that can be dried with success are increased.

Evaluating methods for determining quality

The Maryland station (coop. USDA) has evaluated various methods used in determining the quality and grades of raw and processed green and wax beans. The quality of snap beans was influenced to the greatest extent by the time of harvesting. The research brought

out that harvesting the beans in two, rather than in one or more than two pickings, was most satisfactory. In similar cooperative research on market quality in asparagus, the station developed an instrument to measure objectively the quality of asparagus spears and the tenderness of the stalks. It can be used for determining the grades of both fresh and processed asparagus.

Maleic hydrazide slows up sprouting

At the Michigan station, research workers are examining many of the new growth-regulating substances that have been found to have a profound effect on the life processes of plants. Recent findings demonstrate that spraying the tops of beets, carrots, parsnips, and rutabagas with maleic hydrazide, a chemical that slows down respiratory activity, 2 to 3 weeks before harvesting, has proved efficient in preserving quality and in preventing sprout and root development in these crops. Onion tops sprayed with maleic hydrazide while they were still green yielded storage bulbs on which sprouting was prevented and spoilage reduced.

At the New York (Cornell) station, successful use of maleic hydrazide to preserve the quality of onions in storage has also been reported. Early Yellow Globe and Brigham Yellow Globe onions, when sprayed about 2 weeks before harvest, stored at 32° and 40° F. for 16 weeks, and then held under conditions similar to those in a retail store, showed a definite suppression of sprouts as compared with the unsprayed check lots. At the Pennsylvania station, recent research indicates that maleic hydrazide sprayed on the foilage of plants affects respiration by partially inactivating or inhibiting one or more of the enzymes.

Controlling bacteria in pickle brine

Research in the processing of cucumbers for pickles has progressed at the New York State and the North Carolina stations. At Geneva, the temperature of the fermenting brine was shown to have specific effects on the type and content of the bacteria, rate and degree of fermentation and rate of curing. Studies at the North Carolina station (coop. USDA) now center around the pectin-splitting enzymes that cause spoilage. Control of this spoilage would save millions of dollars to the pickle industry.

ORNAMENTAL PLANTS

Under today's accepted pattern of living, the plants and shrubs surrounding a family dwelling are regarded as much a part of the home as the house itself. The growing of the relatively sensitive trees, shrubs, and herbaceous plants, however, is greatly affected by variations in climate and weather, of which there is wide diversification in the United States. For this reason many experiment stations include in their program studies dealing with ornamental plants as these can be adapted to different parts of the State. Such research is usually closely related to the main fields of horticultural research. It has yielded some new and outstanding varieties, together with numerous improved cultural, handling, and marketing methods, a few recent examples of which are summarized below.

Rose Breeding

At the Arkansas station, a new, pink, climbing rose, named Miriam's Climber, has been developed. Under Arkansas conditions, this variety compares favorably in cold resistance with established commercial varieties. It is reported to be resistant to powdery mildew and to have some resistance to black spot and anthracnose. Miriam's Climber has shown outstanding vigor and when budded to *Rosa multiflora*, has produced canes 15 to 20 feet long in a single season.

Progress has been made at the Pennsylvania station in the artificial culturing of rose embryos. This laboratory technique has been used by the breeders of flax, peach, apple, pear, plum, and other species to expedite their breeding program. Under aseptic conditions, the embryo was transplanted to a nutrient media and allowed to grow until it could be transplanted to open flats. This method makes it possible to produce 2 generations per year in comparison with 1 generation every 12 to 18 months under the usual procedure for growing rose seedlings.

Cultural Practices

At the Hawaii station, a method has been developed for producing chrysanthemum flowers continuously throughout the year. This has been a boon to the million-dollar cut- and lei-flower industries of the Territory. Blossoming of the plants was regulated by the duration of the light they received each day. Flowers were produced after the plants were moved from an environment having long days to one managed so that the daylight hours were short. The problem was one of modifying well-accepted photoperiodic principles to the climate of the Hawaiian Islands.

Improved methods of propagating woody shrubs have been reported at the Massachusetts station. When a fungicide, Phygon XL, was used with indolebutyric acid, a better rooting response was obtained with softwood cuttings of species of *Cornus*, *Clethra*, and *Rhododendron*. This fungicide also improved the rooting of fall and winter cuttings of *Thuja*, *Juniperus*, and *Abies* when added to solutions of naphthaleneacetic or indolebutyric acids.

Heavy losses of greenhouse carnations are sometimes experienced due to bacterial wilt. At the Ohio station, applications of gypsum to the soil in which carnations are growing, reduced the loss from bacterial wilt from 99 percent to 10 to 40 percent. The Ohio station estimates that as a result of the use of gypsum by growers, a gross saving to the carnation industry of over \$15,000,000 has been realized.

At the Pennsylvania station, attention has been given to solving the problem of leaf burn on the foliage of the Croft type of Easter Lily which is popular in the Easter trade. This problem has also been the subject of research in the Department and at the Ohio and New York (Cornell) stations. The Pennsylvania station reports that when soil nitrogen was maintained at a medium to high level, the malady was avoided.

Recent findings at the Wisconsin station are of great interest to horticulturists as well as foresters. A promising means of vegetatively increasing desirable types of white pine through the use of root cuttings has been reported. From 50 to 90 percent of the white pine cuttings taken from 3- to 4-year-old trees from the middle of July

until the middle of September usually formed roots. Growth-regulating substances such as indolebutyric and alpha-naphthaleneacetic acids increased the number of successful cuttings. For the perpetuation of select ornamental types of white pine, as well as the increase of types apparently resistant to the white pine blister rust, this method of propagation is noteworthy.

PLANT DISEASES AND THEIR CONTROL

Problems in plant disease control change from year to year. The nature and tempo of all life is one of constant change to meet the circumstances of environment. Nowhere does this fact become clearer than in the behavior of the minute forms of life responsible for many plant diseases. That is why a new plant disease, or one previously put under control, may gradually or suddenly loom again as a major crop production problem. Research in plant pathology, therefore, has to be a continuous undertaking so that farmers and the Nation may be protected against crop failures such as, for example, the sporadic outbreaks of wheat stem rust. That such epiphytotics have been less serious and widespread in recent years is due to the constant vigil of the plant pathologists at State experiment stations and in the Department agencies.

The value of plant disease research lies not alone in ascertaining the cause, effect, and efficient control of plant diseases and thus increasing crop production and crop quality. Frequently studies made on plants contribute substantially to progress in other fields of scientific endeavor. For instance, plant pathologists at the Wisconsin station for many years have studied how abnormal growths begin, what keeps them going, and how they can be stopped. Since many of the fundamental processes in plant and animal cells are similar, findings on such plant growths at this and other experiment stations are contributing fundamental information that may prove helpful in the fight against cancer. The information is useful in the widespread research effort of medical scientists to better understand the nature of cancer and tumors in human beings and to find means of preventing or controlling them more effectively.

Plant pathologists and chemists at the Wisconsin station have also found a protein in spinach that retards the development of a virus in tobacco plants. They have synthesized this protein in the laboratory. There is a possibility that this finding may lead to a method of combating successfully virus diseases in humans and animals. It represents the kind of promising contribution plant pathology research is making toward disease control in general.

Over 700 research projects dealing with plant diseases and their control are supported by Federal-grant funds at State experiment stations. Representative examples of current research on plant diseases are here presented.

Diseases of Field Crops

Stem rust of wheat

Stem rust of cereals and of wheat in particular has been a serious disease in the United States for a long time. During the past 25 years, however, remarkable progress has been made in reducing the losses from stem rust through breeding rust-resistant varieties and by eradi-

cating nearly 400 million rust-spreading barberry bushes from 18 States. Except for the occurrence of stem rust epiphytotics in 1935 and 1937, when conditions were extremely favorable for its development, this disease was of comparatively little significance until its spectacular outbreak in 1950 on the common bread spring wheats and on the durum or macaroni varieties of wheats. Stem rust was particularly devastating on the latter group.

This rust epidemic was caused by race 15B, the most virulent race of stem rust ever found in North America. There are now over 200 described races of stem rust. Race 15B was collected in 1939 on barberry bushes in Iowa and was identified by the Minnesota station (coop. USDA) as extremely virulent on wheat, but it was not until 1950 that its spread was so extensive. That year it was found on wheat in 15 States, from Texas to northernmost United States. It was particularly damaging, however, to the durum wheats in northwestern Minnesota and in North Dakota where the yield of these wheats was reduced 35 and 22 percent, respectively, or a total of 10 million bushels. And this figure does not include reduction in test weight and quality. The Minnesota, Kansas, Texas, North Dakota, and other stations (coop. USDA) found that none of the commercially grown bread or durum wheats is resistant to race 15B. They found, however, that certain wheats introduced from Kenya, East Africa, South America, and Portugal were resistant, and an extensive cooperative breeding program between the Department and many of the State experiment stations has been launched to incorporate into our commercially desirable wheats the resistance to race 15B carried by these foreign wheats. This breeding program has already showed marked progress.

In the extensive program of breeding for disease resistance at the Kansas station (coop. USDA) the reaction of nearly 1,700 wheats to stem rust race 15B was determined at fluctuating temperatures in the green house. The common wheat varieties, Webster, Gabo, Maria Escobar, Red Egyptian, Egyptian No. 95, and several selections from Kenya, as well as some interspecific and many intergeneric hybrids, were resistant. Selections from crosses of *Agropyron elongatum* (slender wheatgrass) \times common wheat showed the highest resistance. Although many of these selections are highly resistant to the virulent race 15B, the California, Kansas, Montana, Oklahoma, Washington, and other stations find that they are not of desirable milling quality. Crosses made at the North Dakota station between durum wheats and Khapli emmer also look promising. Numerous selections from crosses made at the Texas station between Kenya and Latin-American wheats have remained essentially rust-free in field trials. Kentana, a variety developed by the Rockefeller Foundation in Mexico, is now being increased in northern Mexico since it was found to be resistant to race 15B. From this extensive research, the possibility of securing effective means of combating race 15B looks promising.

Because the weather conditions were unfavorable for the development and spread of rust during the spring and summer of 1951, there was comparatively little stem rust on wheat, but from a study by numerous stations (coop. USDA) it was found that race 15B is as prevalent as any of the other races. If the conditions should be favorable for rust development during the fall and winter, there are probably sufficient spores to furnish inoculum to infect susceptible

grasses and cereal plants in the southern United States, where the rust can survive the winter and move north next spring to again attack the wheat crop.

Wheat streak mosaic

Although wheat streak mosaic was found in Kansas in 1932, it had not reached epiphytotic status until 1949 when it reduced the crop by 15 million bushels. The disease has now been found in Colorado, Iowa, Nebraska, Oklahoma, South Dakota, and Texas. The method of spread is not fully understood but it is suspected that insects are responsible and the Kansas, Nebraska, Oklahoma, and South Dakota stations are devoting much effort to research on this problem.

None of the commercial wheats is resistant to wheat streak mosaic. Testing the reaction of varieties had always been a tedious, time-consuming task, since each individual wheat plant had to be hand-inoculated. Recently, however, cooperative research between the Kansas station and the Department has developed a spray method of inoculating large numbers of plants in a relatively short time. This will enable the testing of many hybrids, selections, and varieties. In addition, some of the *Agropyron* (grass) \times wheat hybrids seem to carry the highest type of resistance. In backcrossing these resistant grass-wheat selections to commercial wheats, much of the desired resistance is usually lost. It is the hope of scientists that by testing unusually large numbers, the required resistance will be retained. Research by both the experiment stations and the Department on this serious disease, as well as on the root rot and soil organisms, which are often found associated with the mosaic disease in the Great Plains area, is needed.

Rusts of oats

Record breaking oat crops have been produced since Clinton and other Iowa (coop. USDA) Bond derivatives have been grown on 95 percent or more of the State oat acreage. The estimated increase in yield resulting from the new varieties over a 3-year period in Iowa was over 166 million bushels valued at 117 million dollars. This high production is being threatened, however, by the appearance of stem rust races 7 and 8 which hitherto had been relatively unimportant. However, fortunately, several resistant oat varieties already developed can replace the susceptible ones.

Another important disease of oats is crown rust. As a result of the screening effect of growing varieties resistant to old races 1, 6, and 7, these hitherto important races have about disappeared from the United States and have been replaced by the new common races 45, 57, 68, and others. To overcome their threat, the Iowa, Arkansas, and other stations are using the Souht American Sante Fe and Landhafer oat varieties as sources of resistance to the widespread race 45 and all other races of crown rust presently known in North America. A number of hybrid combinations are now available from which it should be possible to develop agronomically desirable selections possessing combined resistance to all presently known races of crown rust, stem rust, and the covered and loose smuts.

Cotton diseases

The South Carolina station found that old, infected cotton stalks left in the field over winter furnished the primary source of infec-

tion for a seedling disease caused by *Ascochyta gossypii*, whereas the New Mexico station (coop. USDA) found that *Verticillium* wilt was spread in the same way. The reduction in yield caused by wilt amounted to 1,049 pounds of seed cotton per acre or 398 pounds of lint. Fiber produced on the diseased plants was inferior in grade and strength. Yarn spun from the fiber was inferior in appearance, grade, and spinnability. Workers at the Arizona station found that the wilt fungus when artificially injected into the cotton seed can live inside the seed for at least 8 months, or longer than the storage period between harvesting and planting. Planting disease-free seed, treating the seed with a recommended fungicide, and destroying old, infected stalks are suggested practices to reduce cotton diseases.

Flax rust

The knowledge that the rust reaction of resistant flax varieties is highly specific is being used in a unique way at the North Dakota station. If a variety is not true to type and mixtures occur, these off-plants can be determined by their reaction to rust. These findings have made a definitely valuable contribution to the maintenance of varietal purity.

Applications of boron at the rate of approximately 30 pounds per acre were found by the Minnesota station to materially reduce rust in flax. Control plants not treated with boron and exposed to late natural rust infection showed 75 percent rust, whereas boron-treated plants had only 22 percent rust. A 90-percent rust infection reduced the yield to approximately one-third of that obtained with 75-percent infection, and 25-percent rust infection nearly doubled the yield over that obtained with 75-percent infection.

Soybean chlorosis

The discovery by the Arkansas station that soybean chlorosis, which usually occurs when beans follow rice in the rotation, can be controlled by the addition of potassium (30 to 80 pounds per acre of available K_2O) or in combination with nitrogen and phosphorus, is of considerable value to the farmer. By following the recommendation of the station, significant increases in yield were obtained when affected areas were treated.

Bacteria overwinter in soybean seed

The North Carolina experiment station (coop. USDA) found that bacterial pathogens that cause pustule, blight, and wildfire were seed-borne and that they overwinter in diseased leaves in North Carolina. Laboratory tests also showed that the three bacterial pathogens can live at least 9 months in sterile soil, but for a much shorter period in nonsterile field soil. There appeared to be a close association in the development of two of the diseases. Wildfire usually followed the bacterial pustule.

Potato diseases

Continuing the comprehensive research program on potato diseases, the Maine station found that the red xylem disease of tubers is of bacterial origin and could be reproduced in the laboratory. For the first time in Maine, anthracnose was identified in stems and tubers.

Definite progress is being made in obtaining resistance to the destructive bacterial ring-rot disease of potatoes, according to a re-

port from the Wyoming station. Of the nine ring-rot-resistant seedlings tested, all but one remained free of symptoms. Further experiments indicate that even though infected seed is planted, certain resistant varieties have the ability to produce plants free of ring-rot symptoms. In the susceptible control, Bliss Triumph, similarly planted, 100 percent of the plants showed ring rot.

Research on a potato virus at the Michigan station shows that it is possible to distinguish virus infection by the rate of metabolism of infected tissue. It was found that the virus infection had no effect on the metabolic rate of the potato tuber itself, but that the very young eyes, or developing buds, showed a remarkably high rate of metabolism in comparison with the normal, if the measurement was made at a certain stage of development.

Another means of detecting virus in potatoes was developed at the North Dakota station. Until recently, there was no way of knowing whether virus X was present in seedstock. It was found that applying juice from infected potato plants and tubers to the leaves of *Gomphrena globosa*, globe-amaranth, produced lesions in a very short time. Therefore, it is possible to test large quantities of seedstock very quickly. These findings are of special value to the foundation seedstock growers as well as to those doing potato-breeding research.

Tobacco diseases

In a survey of plant beds during the extremely severe outbreak of wildfire in tobacco in 1950 the Kentucky station found that beds plowed in the fall were free of wildfire, provided they were well drained. Spring-plowed beds were frequently affected even though treated with bluestone-lime. This discovery supports the earlier findings of the station that the causal bacteria live over winter on the living roots of plants. Experiments concluded at the Virginia station show that no root disease problem developed in old tobacco plant bed sites over a 4-year period, in which the soil was treated annually with calcium cyanamide and urea. Soil fumigation with methyl bromide proved effective in controlling weeds and diseases of tobacco plant beds, according to the Virginia and North Carolina stations and the Connecticut Tobacco Laboratory.

Fruit Diseases

New techniques for studying fruit diseases

In an effort to determine why it is so difficult to replant peach orchards successfully on old peach soils, the California station has developed a method for growing disease-free peach embryos in test tubes. Extracts from old peach roots, chemicals, and soil organisms may later be added to the tubes to determine what agents and conditions produce growth disorders in new plantings.

Another promising method that appears to have unlimited possibilities in plant disease research was developed by the Oregon station. It is a rapid method for looking into leaves and flowers, by the use of a precision vacuum technique and the infiltration of fluids harmless to cells into spaces of the tissue formerly occupied by air. The method has been used in virus diagnosis and only 40 seconds is required to prepare material.

Continuing their research on brown rot in commercial peach orchards, plant pathologists at the Delaware station found that pre-harvest sprays do not control fruit infection, but that summer sprays are of value. The research showed that blossom sprays are the most important control applications, and that a combination of blossom sprays and summer sprays gives the best control of fruit infection.

The amount of brown rot in peach orchards is directly correlated with the prevalence of a group of insects called the Pentatomids. These insects were found by the Illinois station to feed on maturing peaches and producing openings sufficient to permit the brown rot fungus to enter and cause decay. The station also found for the second year that Phygon-XL was superior to all other treatments for controlling blossom blight in peaches.

Control of apple scab

Apple scab continues to be one of the most widespread and serious diseases of this extensively grown fruit. Research at the New Hampshire station lends support to evidence found at some of the other stations that Phygon-XL is an excellent protectant against scab infection. The station reports that four sprays with this material are equivalent to seven sprays with a sulfur compound. On the other hand, this material will not eradicate the scab fungus once infection has occurred. Under such conditions, the organic mercurials have an excellent eradicated action and can be used up to 5 days after infection has taken place.

Experiments by the West Virginia station on the control of apple diseases showed that ferbam applied in mid-June and again in late July provides adequate control of Brooks' spot, sooty blotch, and flyspeck, and avoids the damage to foliage caused by the previously used bordeaux mixture.

Virus diseases of stone fruits

Many of the experiment stations (coop. USDA) have made significant contributions during the past year toward a better understanding of the virus disease complex of stone fruits. Research on stone fruit viruses, organized on a regional basis several years ago, is beginning to bring results. Under this arrangement, members of the regional technical committees have a better opportunity to meet and discuss their problems. This leads to a freer exchange of information so that there is less chance for duplication of effort.

Data accumulated by the Pennsylvania station indicate that the ring spot virus spreads very rapidly through cherry orchards under certain conditions. Yields were reduced about 40 percent during the year in which "shock" symptoms appear. Around 11 million pounds of cherries are produced annually in the State, having a farm value in 1950 of 2 million dollars. Since the only practical way of controlling virus diseases is to prevent their introduction into new plantings, over 80,000 indexed disease-free trees were produced under the supervision of the Pennsylvania station for distribution to growers.

Oregon nurserymen, as well as orchardists, are now benefiting greatly from better stands of cherries, higher quality stock, and better sales developed as a result of the research and extensive indexing program developed by the Oregon station. Investigators at this station

have also obtained a lead that helps to explain why stone fruit viruses cannot be transmitted mechanically. They found that normal cherry juice contains a strong virus inactivator which readily makes even stable viruses, like tobacco-mosaic, noninfective. Connecticut station research lends support to these results. Of interest was a fraction extracted from wild black cherry, a species naturally immune from X-disease. Applied to peaches for 10 days at concentrations of 1 to 10,000 and 1 to 20,000 this fraction produced complete immunity from X-disease.

Further study by the Washington station on the western X-disease virus showed that three species of leafhoppers, as well as the geminate leafhopper, previously incriminated, are transmitters of the causal virus. The Utah station (coop. USDA) found that the western X-virus was transmitted from chokecherry to peach and the western X-little cherry virus from sour and sweet cherry to peach by the same leafhopper, *Colladonus geminatus*. The Oregon station also showed that western X-virus inoculations from peach to cherry were successful. These findings help to explain how this virus spreads in orchards of stone fruits.

The Wisconsin station's X-disease studies on the chokecherry showed that there are at least four strains of X-virus in the State. Nine species of *Prunus* were found to be new hosts for this virus. Only *P. serotina* was considered to be immune. That virus diseases of stone fruits are costly was also revealed by the Wisconsin station. Experiments conducted on paired trees in commercial orchards in Wisconsin showed that the cherry yellows virus reduced yields 72 percent. In a different orchard, reduction in yield from cherry yellows was 66 percent and in numbers of fruit 72 percent for 39 paired trees.

Yellow leaf roll, a destructive and apparently new disease, was found affecting at least 7 out of 12 common varieties of clingstone peaches in certain parts of California, according to station workers. Other newly discovered virus diseases on California stone fruit trees are: Necrotic ring spot on Gaume peach, bunch top on peach, and a rugose mosaic on sweet cherry.

Quick decline in citrus

Quick decline, the serious virus disease of citrus, continues to spread slowly into new areas of the State, according to researchers at the California station. The slow movement is probably due to the comparatively small numbers of the insect vector, *Aphis gossypii*, and the apparent inefficiency of this insect in disseminating the virus. It is now known that the Mexican lime seedlings develop the characteristic leaf symptom of quick decline disease in a short time; hence, the Mexican lime plant provides a much needed index host that will greatly facilitate research on this disease. As a result of its research and wide experience and of a critical review of the literature on citrus diseases, the California station concluded that stem-pitting disease of grapefruit in South Africa, the lime disease in the Gold Coast Colony of West Africa, *Tristeza* disease in South America, and quick decline in California are caused by the same virus or closely related viruses.

Vegetable Diseases

Tomato disease control

The Ohio station reported that formulations containing copper gave the best control of tomato diseases, particularly those that usually attack the fruit. The fixed coppers and bordeaux mixture were outstandingly effective and the best control was obtained by a fixed copper to which an adhesive known as P. E. P. S. had been added. The ethylene bis-dithiocarbamates (Dithane and Parzate) also gave excellent results. The Maryland station obtained similar results with these sprays on tomatoes. It recommends the zinc dithiocarbamates for general tomato disease control.

Control of cabbage diseases

The Mississippi station found that applications of fungicides for the control of cabbage downy mildew in coldframes could be reduced from twice to once weekly, provided the spray or dust schedule starts as soon as plants are up to a stand. Effective control was obtained with Spergon Wettable, Cop-o-Zink, and Dithane Z-78. The Massachusetts station was successful in controlling clubroot of cabbage with a mixture composed of limestone, 124.8 grams, and mercuric chloride, 0.35 gram per square foot, applied 60 days ahead of or immediately before planting. Significant progress has been made by the Wisconsin station in developing measures that will provide resistance to both clubroot and yellows.

Tree Diseases

Many of our shade and forest trees are attacked by various diseases that weaken and often kill them. Several of the stations, with the aid of commercial grants, are devoting considerable effort to the control of tree diseases.

Experiments at the Iowa station during the past 2 years show that the destructive sycamore and oak anthracnose can be effectively controlled by spraying with several fungicides. The effective materials sprayed at 600 pounds pressure were: Bordeaux, 4-4-50; Tribasic Copper Sulfate, 4 pounds per 100 gallons; Fermate, 1½ pounds per 100 gallons; Phygon, three-fourths pound per 100 gallons; and Puratized, 1 pint to 100 gallons of water. Sprays applied to the trees when dormant, and again when the buds were breaking, gave the best results.

An inexpensive "dry pack" method of treating maple and elm to retard or prevent Verticillium wilt has been developed by the Rhode Island station. Formulations of salicylic acid, azo dye, and a numbered dyestuff gave excellent control of this disease. When released for public use, this will be the first control measure available for this major tree disease.

FIELD CROPS RESEARCH

A comprehensive summary of progress in the recent development of new varieties of cereals, fiber and oil seed, root and sugar crops, and tobacco was given in the 1950 report. This type of research, also that dealing with effective tillage, fertility, cultural, and harvest practices continues to occupy a major position in the experimental programs of the stations and the Department. Because of the major contributions which the results of these experiments are making toward in-

creasing the Nation's food and fiber output, a few examples of the advances made during the past year are given here.

Corn Improvement

Efforts are being made to find corn hybrids that are resistant to European corn borer and with other superior qualities. Ohio station (coop. USDA) hybrids, such as K62, W64, C54, which also show resistance to stalk rot, have substantially outyielded older hybrids in the absence or serious infestation of borers. Ohio C54, a new hybrid, is said to be the most resistant of all corns to the borer. The Minnesota station has developed hybrids highly resistant to the first brood and highly tolerant to the second brood, which soon may be in commercial production.

New commercial hybrids, all tolerant to corn borer damage, made available by the Iowa station (coop. USDA) are Iowa 4376, 4470, and 4537 for northern and central Iowa; and Iowa 4531, 4525, and 4527 for southern Iowa. The inbred lines in single crosses to be used in producing the new hybrids have high yield, long ears, stiff stalks, and high resistance to lodging and stalk rot, items particularly important in borer-tolerant corn. As an example of performance, Iowa 4527 has yielded as high as the widely grown U. S. 13, and had only about half as many dropped ears and lodged stalks.

Indiana 803-A, a corn hybrid in which all four parent strains are resistant to first brood establishment, and Indiana 909, a late white hybrid adapted to southern Indiana, both Indiana station (coop. USDA) contributions, have outstanding yield records, surpassing U. S. 13 by 10 and 8 bushels per acre, respectively.

A new yellow hybrid, Mo. 804, released by the Missouri station (coop. USDA) has averaged about 6 bushels more per acre than Mo. 8, next best for the area. Mo. 804 is more vigorous, has about half as many root-lodged plants and about one-third fewer stalk-lodged plants, is less subject to ear rot, and is much easier to harvest with a mechanical picker than Mo. 8.

Two new promising early hybrids of the Nebraska station (106-110 days maturity at Lincoln) have outyielded Iowa 4316 in several years' tests. Nebraska 1217C compares favorably with hybrids of similar maturity and yield and root rot and stalk lodging. Nebraska 1268B has an excellent yield record and is resistant to lodging and stalk breaking.

The South Dakota station recommends two new high-yielding yellow hybrids for eastern South Dakota where growing conditions are generally favorable for corn production. South Dakota 262 (90-day maturity) is resistant to root and stalk lodging and has excellent emergence and seedling vigor. South Dakota 270 (100-day) plants have uniform size and shape, wide dark-green leaves, and good standability.

White hybrids of the Virginia station with high quality of grain have shown superior performance. Va. 7368 has stood up better than any other hybrid in eastern Virginia tests and the late Va. 9100W has been the highest yielding white. Va. 9002, a very promising experimental yellow hybrid in the southern Piedmont and eastern Virginia areas, is a high yielder with good standability and high resistance to leaf and stalk diseases. Another yellow, Va. 9045, noteworthy for

high resistance to leaf blight and stalk rot, evidently will be best adapted to the Piedmont.

Georgia 103, a new white prolific hybrid of medium maturity, released by the Georgia station (coop. USDA), has good resistance to weevil and to lodging and surpasses Georgia 101 and Dixie 17 in these respects. It is recommended for the Piedmont and Upper Coastal Plain. Georgia 281, a full-season white hybrid developed by the Georgia Coastal Plain Station (coop. USDA) and widely adopted in the region, approaches Dixie 18 in yields and ranks with Florida W-1 and Dixie 18 in weevil resistance.

Proper spacing and fertility conditions are essential for maximum results from the superior hybrid corns. The Minnesota station finds that 10,000 to 11,000 plants per acre have given satisfactory results on sandy soils, 15,000 to 16,000 on medium-textured soils, and 20,000 plants on heavy-textured soils or those with slow drainage and high water-supplying power.

For best corn yields on upland soil low in fertility, the Arkansas station indicates spacings of 12 to 14 inches apart in 42-inch drill rows to provide between 10,000 and 12,000 plants per acre. Under favorable moisture conditions, when 60 to 90 pounds of nitrogen per acre was applied to these thick plantings largely when plants were knee high, corn yielded more than 100 bushels per acre.

The Ohio station (coop. USDA) found that full-season hybrid corn planted in 60-inch rows will yield as much corn on good land during a favorable season as an early hybrid in 40-inch rows. Building on this finding the station worked out a new pattern for growing corn, wheat, and meadow crops in sequence, that is adapted especially to conditions in the East and to the use of small tractor (or horse drawn) wheat seeding equipment. This sequence provides corn for feed, wheat for cash and bedding, and meadow for forage and soil building. The 60-inch spacing permits seeding of wheat with small tractor machinery between standing rows of unharvested corn at the ideal time, and the corn may be picked with a mechanical harvester after it is fully dry.

Wheat

The several promising new wheats released to growers by the experiment stations and the Department are characterized by high yields, resistance to diseases and environmental hazards, adaptation to locality and to mechanized production, and superior milling and baking qualities.

Lee, an early, bearded, leaf-rust-resistant hard red spring wheat developed by the Minnesota station (coop. USDA), is especially well-suited to the eastern and southern part of the spring wheat region where leaf rust is a serious problem. It is, however, susceptible to loose smut, bunt, scab, and bacterial black chaff, and race 15B of stem rust. In variety tests Lee has yielded as well as or higher than other recommended varieties, heads out 2 to 4 days earlier, and has a slightly higher weight per bushel, and the plants are 2 to 3 inches shorter.

Kiowa, a new, stiff-strawed hard red winter wheat developed by the Kansas station (coop. USDA), is especially adapted to western Kansas. It is highly resistant to bunt, does not shatter easily, has

a high test weight and satisfactory milling and baking qualities. Kiowa has yielded from 1 to 3 bushels per acre more than Comanche and its test weight averages a pound higher, but it is more susceptible to loose smut than Comanche or Tenmarq.

Seneca wheat, released by the Ohio station (coop. USDA), resembles the soft red winter Thorne, a sister selection, but yields better, and has slightly stiffer straw, and a higher test weight. Seneca is resistant to prevalent races of loose smut but susceptible to scab, has good milling qualities, and is satisfactory to the trade.

Saline, a soft red winter wheat developed by the Illinois station (coop. USDA), is a rather tall, bearded, white-chaffed variety with moderately stiff straw. It has an outstanding yield record in central and southern Illinois, and has rated satisfactory in milling and baking tests. It is resistant to mosaic and to most leaf and stem rust races but is susceptible to loose smut.

Genesee wheat, a soft white winter variety developed by the New York (Cornell) station (coop. USDA), has out-yielded by 8 percent the average of Yorkwin and Cornell 595 in New York tests, and has an outstanding record elsewhere. It is a beardless, brown-chaffed, yellow-strawed wheat that brings together many of the best features of Yorkwin and Cornell 595, including the high loose smut resistance of the latter. The quality of its grain and flour is excellent.

Pennoll, a new soft red winter wheat derived by the Pennsylvania station and consistently outyielding other soft red winter varieties, is expected to meet the needs of the State's millers for a strain with higher milling quality than Thorne. It is medium-tall to tall, beardless, white-chaffed, stiff and yellow strawed, and relatively free from shattering. It matures slightly later and its test weight is nearly 2 pounds heavier per bushel than Thorne. Pennoll has shown resistance to bunt and loose smut under natural infection, but is susceptible to leaf rust.

Oats

Branch oats, a new productive, tall white varitey, released by the Wisconsin station (coop. USDA), has a straw of medium strength and matures in late midseason. It outyields most varieties currently grown in Wisconsin and is recommended for the northern two-thirds of the State.

Mo. 0-205, a high-yielding, strong-strawed new oats developed by the Missouri station (coop. USDA), is said to be the only variety at present adapted to Missouri conditions that is resistant to both Victoria blight and race 45 of crown rust. It resembles Columbia and Mo. 0-200, heading about 2 days later than these, yet is 3 days earlier than Clinton oats. The kernels are brownish-gray, striped, with thin hulls and high test weight.

Craig oats, higher yielding and more crown-rust resistant than most present varieties, developed by the New York (Cornell) station (coop. USDA), is expected to aid New York farmers who need a later maturing oats to fit into their harvesting schedules.

Southland oats, a medium early, upright, vigorous variety adapted to the Gulf Coast area and brought out by the Florida station (coop. USDA), is resistant to Victoria blight and moderately so to crown rust, but is susceptible to stem rust and also to cold weather. It has

a spring growth habit, dark bluish-green foliage—broad coarse leaves—and yellowish-white kernels.

Overland and Cody, two superior new oats for the Northwest, developed by the Idaho, Washington, and Iowa stations (coop. USDA) (and also Wyoming station with Cody) are resistant to crown and stem rusts and smut, but not to Victoria blight. Overland, which has exceptionally stiff straw, tends to be 6 to 10 inches shorter and heads 3 to 6 days earlier than Victory, Colorado 37, and Bannock, productive varieties widely grown on irrigated lands in the Northwest. The high-yielding Cody, a white oats with short stiff straw, is especially adapted to fertile irrigated areas and is recommended for irrigated and dry-land farms in Wyoming. Both varieties excel as companion crops for clover and grass seedings.

Shasta oats, a tall late-maturing high-yielding variety developed by the Oregon station (coop. USDA), is adapted for irrigated areas of the Klamath Basin and central Oregon. It combines the smut resistance of Markton with the productiveness of Victory, and has outyielded its parents and Kanota in tests.

Barley

Mo. B-400, a new winter barley developed by the Missouri station (coop. USDA), surpasses older varieties in yields and disease resistance. It is bearded, matures about 5 days earlier than the commonly grown Reno which it outyields, and has a stiffer straw but similar winterhardiness. Mo. B-400 shows resistance to mildew and to local collections of brown loose smut affecting present winter barleys, and more resistance to yellowing and spot blotch injury. Edda barley, an early, stiff-strawed high-yielding variety, introduced from Sweden by the Alaska station (coop. USDA), is recommended for all barley-growing areas in Alaska. Edda is of good malting quality and also entirely acceptable for feed, being higher in total digestible nutrients than common barleys grown in the United States.

Rice

Century Patna rice, a new high-quality variety, was developed by the Texas station (coop. USDA) to meet needs of growers for adapted early-maturing, long, slender-grain varieties so that the harvest of premium-quality types of rice can be prolonged. It matures in about 120 to 125 days, has short stiff straw and smooth hulls, yields well, apparently is well suited for harvesting by the combine-drier method, and is adapted to Arkansas, Louisiana, and Texas. Century Patna may be grown to advantage along with the midseason Bluebonnet and the late-maturing Texas Patna and Rexoro, all long, slender-grain varieties, in order to extend the harvest period. These high-quality varieties, evidently preferred by both domestic and principal foreign markets, have sold at premiums over medium- and short-grain types during the last 7 years.

Rye

Pierre rye, a winter-hardy variety developed by the South Dakota station, has surpassed Dakold and Emerald in winter survival, average acre yields, and test weight per bushel. Pierre is expected to

outyield the better strains of common rye when winterkilling is a factor.

Cotton

Cobal cotton, a new variety bred by the Tennessee station and the Department, promises to add many thousands of dollars to the incomes of Tennessee cotton growers. Cobal, superior in many ways to cottons commonly grown in the State, is an early-maturing variety, opening slightly before Empire. The classer's staple length is full $1\frac{1}{16}$ to $1\frac{3}{32}$ inch, and lint turnout is 37 to 40 percent. Its bolls are large, fluffy, and easy to pick. The plant type is medium vigorous and well adapted to all cotton soils in Tennessee.

A new strain of cotton 1517C, developed by the New Mexico station (coop. USDA), is a high-yielding variety with good spinning quality. It has outyielded 1517A and 1517B, superior strains produced commercially in New Mexico and in parts of Arizona and Texas, and outperformed them in other characters, and is as tolerant to *Verticillium* wilt. Its high yields are due in part to earliness and strong seedling vigor.

Flax

Redwood flax, developed by the Minnesota station (coop. USDA) combines high oil content and quality with superior yield and disease resistance. It is resistant to all races of flax rust now known to occur in North America and also to wilt, but is moderately susceptible to pasmo. Redwood is expected to replace much of the acreage now planted to rust-susceptible Dakota and Koto and also part of the acreage of selection B5128 because of its earliness and better oil quality. Redwood straw rates high in fiber characteristics, making it useful in the manufacture of high-grade paper.

Potatoes

Cherokee, the first potato variety with high resistance to both late blight and scab, released jointly by the Indiana and Iowa stations and the Department, holds promise for production on Middle Western soils now badly infested with scab organisms. It is a midseason variety, maturing about 10 days later than Cobbler, and has given high yields and a high percentage of U. S. No. 1 potatoes on muck soils. Cherokee tubers are egg-shaped with a white skin and have higher specific gravity and are more attractive than those of Cobbler.

Pungo, a new late-blight-resistant potato developed by the Virginia Truck station (coop. USDA), has outyielded Irish Cobbler by 25 percent at Norfolk and by 75 percent on the Eastern Shore. Pungo tubers resemble those of Sebago—slightly rougher although not so rough as Irish Cobbler. Pungo has good cooking quality, and in Maine tests it was similar to Green Mountain in specific gravity and showed a satisfactory content of dry matter.

The Canoga potato developed by the New York (Cornell) station is noteworthy for the exceptionally fine flavor and white color of its cooked tubers. The tubers are thick, square-round, and creamy-skinned; and the flesh is white, mealy when baked, and does not slough when boiled. Yields approach those of the high-yielding Kennebec which it slightly surpasses in specific gravity. The plant,

resistant to leafhoppers and tarnished plant bugs, matures about 10 days later than Katahdin. The tubers have not shown symptoms of net necrosis or other internal discoloration.

Sweetpotatoes

Goldrush (L-241), the new sweetpotato variety developed by the Louisiana station (coop. USDA), sets a large number of uniform roots per hill, has excellent cooking and canning quality in Louisiana, and is resistant to *Fusarium* wilt, a serious disease in some growing areas. Goldrush has approximated the standard Unit 1 Porto Rico in yield but produces slightly smaller sweetpotatoes, with fewer jumbos and more U. S. No. 1's. Goldrush has a deep copper skin, which appeals to the quality-conscious consumer. When planted early, even the small sweetpotatoes produced by Goldrush have good shape, and hence where adapted are ideal for the canner who likes to pack small whole sweetpotatoes in sirup.

Sorghums

Hi-Hegari, a new sorghum for silage and forage is a Texas station development (coop. USDA) expected to alleviate shortage of bundle feed brought about by emphasis on grain sorghums. It has the high quality and palatability of Hegari with similar maturity and adaptation, but yields about 20 percent more forage.

Sart, a new variety of sorgo for sirup production, released by the Mississippi station and the Department, is noteworthy for its tall stalks—12 to 25 feet on good land in a good season—stout stems, high juice and sugar content, and large yields of good quality sirup. The late-maturing Sart in tests in Mississippi averaged 444 gallons per acre or about 10 percent more than the widely grown Hodo sorgo. It carries resistance to leaf anthracnose and rot but not to rust and some other leaf diseases.

Spoilage of a large part of the broomcorn crop, when allowed to dry in the field, may be avoided by use of a successful drying method developed by the Texas station. Broomcorn of a uniform green color was efficiently obtained by field curing 24 to 36 hours to reduce moisture content, stacking in six layers 6 inches deep with provision for a minimum of 65 cubic feet of air per square foot of floor area, and a drying temperature not exceeding 150° F.

Sugar Beets

That better keeping sugar beets cut storage losses is shown by the Colorado station (coop. USDA), which indicates the probability that beet sugar factories can operate over a longer season, in spite of the shorter digging period that has come with mechanical harvesting. The tendency of sugar beets in big piles to spoil and the consequent reduction in sugar yield, with an estimated loss as high as \$10,000,000 a year, had created a major problem. Earlier findings indicated that forced ventilation of large piles of beets with chill night air cuts the loss of sugar content at least a third; now the loss can be cut still more by breeding types of beets with roots of lower respiration rate and greater resistance to rots than the curly-top-resistant

variety U. S. 22/3 and other commercial sugar beet varieties used by farmers. In Colorado the progenies of several selected mother roots have shown definite improvement as "keepers" over the parent variety U. S. 226. They promise to provide the basis of a new variety for regions subject to leaf spot epidemics.

Sugarcane

Superiority of C. P. 36/111, a new variety of sugarcane for sirup production, was proved in experiments of the Mississippi station and the Department. C. P. 36/111 has given excellent stands as first- and second-year stubble and produces rapid upright growth which shades the land early and facilitates cultivation and weed control, and lowers cost of harvesting. Leaves are easily stripped when the stalks reach the proper stage for harvest. The straight stalks greatly aid milling operation. Juice recovery approximates that from C. P. 29/116. Clarification of juice and evaporation is excellent and results in a light amber sirup. Cane yields per acre average about the same as Co. 290 and C. P. 29/116; sirup per ton of cane runs from 1 to 2 gallons above the two standard varieties and is of good quality.

The older sugarcane varieties in the sugar-producing parishes of Louisiana have gradually been replaced by the superior C. P. (Canal Point) varieties, introduced by the Department in cooperation with the Louisiana station. The older varieties current when mosaic nearly ruined the Louisiana sugar industry about 25 years ago have entirely disappeared. Now the newer C. P. varieties are continually pushing older C. P.'s into lower percentage ratings and finally out of the acreage ratings. C. P. 36/105, which currently occupies one-third of the Louisiana sugarcane acreage, increased eightfold since 1947 and went up 12.85 percent in 1950. C. P. 34/120 dropped 5 percent and Co. 290, an early introduction from India, lost 7 percent.

Tobacco

Tobacco suckers have been effectively controlled by the North Carolina station through application of less than a teaspoonful of mineral oil to the cut end of the stem just after topping the plant. The operation is facilitated by the development of a clipper which tops the plant and applies the oil in the same movement. Growers using the new method may be able to save up to \$10 per acre compared with customary ways of topping and hand-pulling suckers.

Havana seed tobacco has responded with higher yields and better qualities to treatment with several alternative fertilizer materials and amendments, in experiments at the Connecticut Agricultural Experiment Station. Tobacco receiving 18 to 20 pounds of copper sulfate per acre returned increases of 13 to 26 percent in crop values without harmful effects to the crop, retarding of the burn of leaf, or undue uptake of copper by the plant. The recommended rate, 20 pounds per acre applied with the usual tobacco fertilizer, should be used with due regard to the status of active copper in the soil, particularly where copper fungicides may have been used.

Better burn, a lighter ash color, a fragrant smoke, and a 5-percent increase in crop values were obtained by this Connecticut station when granite stone meal (8 percent potash), a product of nearby quarries,

was used as one of the potassium sources in tobacco fertilizer. For Connecticut tobacco, 175 pounds per acre of nitrogen applied as ammonium nitrate resulted in nearly the same crop value as that obtained from 200 pounds of cottonseed meal nitrogen. Ammonium nitrate gave promising results as a side dressing to supplement a 5-4-8 formula, thus furnishing plant food enough to equal the usual 8-4-8 grade. Tobacco crop values obtained by the application to the soil of half poultry manure and half commercial fertilizer were as good as where fertilizer alone was applied. Since the manure is relatively low in potassium, a potash carrier should be added in compost or applied in a side dressing.

FORAGE CROPS, PASTURES, AND RANGES

Grassland agriculture received added impetus in 1950 with the establishment of a Grasslands Program to be carried out jointly by the Department and the Association of Land-Grant Colleges and Universities. This program has as its aim the improvement of the Nation's grasslands, as a basis for balanced livestock farming, sustained abundance, and good nutrition. Increasing demands are continually being made upon agriculture to expand the production of meat and other livestock products to meet food needs both at home and abroad. This calls for more abundant and cheaper livestock feeds, and past research has proven that grasses and legumes in the form of roughages, pastures, and grazing lands are the most economical sources of such feeds. Besides furnishing feed for increasing numbers of livestock a system of balanced grassland agriculture will build up and maintain soil resources which can be called upon in time of need for increased supplies of grain, oilseed crops, and cotton.

The present status of grassland farming can be attributed in large measure to research by experiment stations, in cooperation with the Department, in all sections of the country. The new program will call for even greater knowledge of grass and legume production and the development of better varieties of these plants. The following represent only a few of the important advances being made in the field of grassland agriculture.

Breeding of Superior Forage Crops

Forage crop breeding is relatively new in the United States but, as grasses and legumes assumed a more important place in agriculture, research was initiated to improve them in much the same manner as breeding research has improved cereal crops. Breeding of the small-seeded grasses and legumes, however, is somewhat more difficult and involved. Most forage crops are naturally cross-pollinated and many are self-sterile, thus limiting the opportunity for inbreeding. Furthermore, perennial forage species require a longer period of time for development and evaluation. Improvement, therefore, is slower. Hybridization is also difficult because of the small size of the floral organs. However, much excellent research is now being done on these crops throughout the country and seed supplies of improved varieties are being rapidly increased. This work has been greatly expanded since the establishment of the National Foundation Seedstock Program.

Probably more attention has been given to research in breeding and improving alfalfa than to the breeding and improvement of any other forage crop; and several new varieties have been introduced in the past few years. Narragansett is the latest variety to be accepted in the National Foundation Seed Project (coop. USDA). This variety was developed at the Rhode Island station. It has given excellent performance under varied conditions and it is estimated that the annual seed requirements will be at least 2,000,000 pounds. The increased yield from planting this amount of seed should be worth at least \$500,000 annually.

The California station has introduced Caliverde, an alfalfa variety resistant to bacterial wilt,* mildew, and leaf spot. The use of this variety should increase the average life of alfalfa stands in California by at least 2 years. This means a reduction of at least 80,000 acres in the amount that must be reseeded annually.

As a result of tests by the Arkansas station, Tift Sudan grass, originally developed by the Georgia Coastal Plain station (coop. USDA), has been recommended for the State. Its use will make possible an increased yield of good-quality forage and a greater livestock carrying capacity. When used as a summer supplemental pasture Tift has increased the grazing period by at least 30 percent. Its high resistance to foliar disease makes Tift a superior variety of Sudan grass.

Piper Sudan grass, developed by the Wisconsin station, combines disease resistance with high yields and low prussic acid content. Under normal conditions Piper Sudan grass will not build up enough prussic acid to be toxic to grazing animals.

Kenland red clover, a new variety adapted to the southern red clover belt, is a result of red clover improvement work conducted at the Kentucky station (coop. USDA). Its outstanding superior characteristic is high resistance to southern anthracnose. In 1950, a total of 1,148,000 pounds of foundation, registered, and certified seed was produced. To date over 90 percent of the seed of each class has been grown in the West as a result of a program developed jointly by the Kentucky station and agencies of the State of California (coop. USDA).

The use of Kentucky 31 tall fescue continues to increase. In 1950 Kentucky growers produced 8,500,000 pounds of seed, valued at \$3,000,000. There has been some criticism regarding the palatability of tall fescue. The Kentucky station has developed a technique for grazing spaced plants with beef cattle to see which plantings appear to be most palatable to them. Any selective grazing of particular plants shown by this method will enable research workers to make selections and eventually develop strains or varieties of improved palatability.

Grassland Management

In order to obtain the benefits which improved varieties are capable of yielding it is necessary that the plants be given proper environments. Poor management produces poor crops and this is true of forage crops as well as cereals, oilseeds, cotton, and other so-called cash crops. Many pastures and hay fields have been disappointing enterprises because of failure to provide good seedbeds, to supply adequate

fertilization and moisture, and to use good judgment in harvesting and grazing. Because of the valuable information now being made available by research agencies, forage crops are receiving more attention and better care, thus increasing the probability of producing high-yielding crops with high nutritive value.

At the Nebraska station alternate grazing of an alfalfa-brome-grass pasture gave 166 animal days of grazing per season and produced 270 pounds of animal gain per acre, whereas continuous grazing gave 148 days of grazing and 191 pounds of animal gain per acre. Furthermore, continuous grazing reduced the alfalfa stand from 55 to 25 percent.

The importance of proper grazing methods has also been shown at the Colorado station. Rotational grazing increased the cow-grazing days by 8 percent and a pasture mixture which included a legume gave an increase of 20 percent in yield. Such a mixture could thus save 1 acre of land for a farmer with a 20-cow herd.

Since grasses are the most widely distributed plants and are found growing on all types of soil, many farmers have assumed that fertilization is not as necessary as for other crops. However, it has been shown that small-seeded grasses, in many instances, give an even greater response to mineral nutrients than cereals.

In 1950 the Matanuska station in Alaska found that smooth brome-grass fertilized with 128 pounds of elemental nitrogen per acre yielded over 2 tons more pasture forage per acre with 9 percent more protein than brome-grass which was not fertilized. Microbiological activity in permafrost soils is low and more fertilizer is required on newly cleared land than on land that has been cropped a few years.

The Maryland station found that boron alone on alfalfa gave a greater response than any commercial minor element mixture and resulted in a saving of from \$6.20 to \$23.80 per acre.

In the Northeast, on large acreages of rough steep land, the surface application of fertilizers is one of the most practical methods of quickly and cheaply increasing the supply of pasturage. The Storrs station (Connecticut) started a quantitative grazing experiment in 1921 on rough unproductive land. A recent 30-year summary reveals that superphosphate alone increased the pasturage 67 percent; superphosphate and lime, 107 percent; superphosphate, lime, and potash, 126 percent; and lime, superphosphate, potash, and nitrogen, 171 percent.

The value of permanent pasture has been demonstrated by the Georgia station. A good stand of Ladino clover and tall fescue during 1 year, carried 1 cow per acre under rotational grazing and produced 1.1 tons of hay, 238 pounds of fescue seed, 1 calf, and 6,288 pounds of milk per acre. Establishment of this pasture cost about \$35 per acre, or about the same as the cost of establishing an annual crop of oats, crimson clover, and ryegrass. Furthermore, the stand consists of perennial species, furnishes a longer grazing season, and has a fertilizer maintenance cost of only \$16 per acre annually.

Ladino clover continues to be a valuable and widely accepted legume. It has been criticized because it is a short-lived rather than a long-lived perennial. However, work at the Michigan station has shown that reseeding of Ladino during August of the second pasture year results in a vigorous Ladino clover-brome-grass pasture in the third

pasture year. The importance of reseeding lies in the fact that even though old plants may suffer winter injury, Ladino's ability to reseed will help maintain a good stand of clover in a well-managed pasture for several years.

The Virginia station found, in testing white clover varieties, that Ladino consistently outyields all other varieties. It starts growth more quickly and grows better during hot summer weather, thus eliminating much weed competition. Ladino clover yielded 2,235 pounds of dry matter per acre, twice as much as its nearest contender, S-100, an English introduction.

Proper Utilization Increases Value of Forages

Forage crops are normally used in the fresh state by grazing animals, or preserved as hay or silage. The most efficient form of utilization depends upon many factors, and in recent years the quality and feeding value of forage crops has been greatly enhanced by improved methods of harvesting, processing, and utilization. Much needs to be done, however, in extending these improved methods.

A recent survey by the Maryland station showed that only about one-fourth of the farms in seven Maryland counties were using pasture programs which approach the intensity of production possible with present knowledge and the plant species available.

Studies by the Alaska station (coop. USDA) reveal that smooth brome grass in the form of silage is the most practical and economical method for feed preservation in the territory. A pound of dry matter in silage was 33 percent more efficient than a pound of dry matter in field-cured hay. Dry matter losses from cutting to storing were 41 percent for field-cured hay and only 21 percent for silage. It was also determined that the average cost of processing brome grass as field-cured hay was \$28.43 per ton of dry matter, whereas silage cost only \$18.05 per ton of dry matter.

Two types of grazing management have been studied by the Ohio Station, using permanent Ladino clover-bluegrass pastures. "Quality" management (which calls for the use of more and smaller grazing units, more frequent mowing, and the use of rest lots) resulted in the maintenance of a better stand of Ladino as compared with that from crops given "quantity" management (under which fewer and larger grazing units are used, little mowing is done, and there are no rest lots). There was little difference, however, in milk production of cattle grazed on the two pastures.

The nutritive quality of hay cut at different stages of growth varies markedly, and gains made by animals utilizing this hay also vary. The Nevada station fed one group of steers during the winter on native meadow hay harvested the first week of July and another group on hay harvested the latter part of August. Steers fed the early-cut hay gained an average of 113 pounds per animal, whereas these on the late-cut hay made an average gain of 53 pounds. However, during the subsequent grazing season the late-cut-hay group gained 1.85 pounds per day as compared with 1.37 pounds gain per day for the early-cut-hay group. As a result, all winter gain advantages were offset by subsequent summer gains. The same results were obtained during two successive years.

Progress Made in Improvement of Native Grasslands

The demand for greater production of meats and the high cost of cereals and supplemental feeds have stimulated widespread interest in range conservation and improvement. Many native grasslands have been at a low ebb for years and the carrying capacity has steadily declined. During the past few years many research workers have devoted full time to problems of range maintenance and improvement and thousands of acres of abandoned cropland in the Western States have been reseeded and are now providing excellent grazing for large numbers of beef cattle. However, many problems remain to be solved and experiment stations are attacking these problems on a broad scale.

Ranchers and range specialists have long needed a better method for evaluating range conditions. Range resources are usually measured in terms of forage produced but research workers at the Arizona station have developed a survey technique which expresses forage production in terms of potential production on a given site. This evaluation not only enables a rancher to know what his present forage production is but also how much his range is producing in terms of its potential. The distribution of a publication from the Arizona station on this subject has resulted in widespread acceptance of the station's range-evaluating method by ranchers and range technicians.

As a result of studies by the North Dakota station (coop. USDA), livestock producers in that State are adopting the plan of adjusting livestock numbers to forage supply. The station has established the fact that there is an apparent close relationship between forage production and the April-to-August precipitation. With this fact as a guide, it may be possible to predict current-season forage yields on the basis of data on soil moisture, precipitation, and vegetative composition.

Experiments conducted by the Oklahoma station (coop. USDA) show that control of sagebrush on range land by mowing or by chemical sprays is a profitable practice. By controlling brush and withholding grazing for two successive seasons the station has encouraged the growth of range grasses and raised the 8-year-average returns above costs from its experimental lands from \$5.07 to \$8.11 per acre. Returns on mowed range land were increased by 60 percent over those on unmowed range.

Large acreages of unproductive sagebrush range land can be economically renovated, as shown by research, at the Colorado station. Areas on which sagebrush was burned produced four times as much forage as unburned areas, and when burned land was reseeded production was six times that on untreated land. Better results were obtained when reseeding was done immediately after the sagebrush was burned.

Establishing stands of grasses on range areas with low rainfall is sometimes difficult. The Wyoming station (coop. USDA) has developed an eccentric disk which leaves shallow pockets in which grass seeds germinate more readily. Recent grazing tests have shown that range land "pitted" by this disk produces about 7 pounds more lamb gain per acre than untreated land. When such areas are reseeded also, the seeded pastures provided twice as many sheep days of grazing as did check pastures on native ranges.

The Utah station (coop. USDA) has found that rotational grazing of crested wheatgrass at a moderate or heavy intensity produces more

beef per acre than any other grazing method. Crested wheatgrass has furnished about 60 to 70 days of spring grazing and has produced about 40 to 50 pounds of beef per acre.

Range livestock on the northern Great Plains may need more protein supplementation during more of the year than has previously been thought necessary. Tests at the Montana station indicate that most range grasses are above the minimum protein level only 3 or 4 months of the year. When the grasses mature on the stem their protein, carotene, and phosphorus contents are considerably below the minimum requirements for mature breeding cattle. On the other hand, shrubs such as greasewood and winterfat are fair sources of protein the year around.

CLIMATOLOGY AND CROP PRODUCTION

In many sections of the United States uncertain and unfavorable weather conditions limit crop production more than any other single factor. These conditions are not limited to drought or excess rainfall. Low temperatures, winds, and, in some instances, a deficiency of sunshine result in lowered crop yields. A better understanding of climatological conditions is needed, not only by the farmer, but by the research worker and plant breeder in order that plants may be developed that are more tolerant of adverse weather conditions in different sections of the country. Long-time weather observations, maintained by many experiment stations, are useful in planning agricultural programs and in recommending varieties of various crops. Microclimatology, a recent development, is producing much valuable information concerning the relation of plants to their immediate environment.

The Missouri station has developed a series of charts which indicate the chances of sustaining freeze damage in different areas of the State. Use of these data enable the farmer to determine the best dates for planting and harvesting crops, thus minimizing his risk while making maximum use of the growing season.

Similar information is being developed at the New Jersey station. "Periods of Anxiety" have been determined for both spring and fall for four different areas of the State. It has been shown that the frost frequency during these periods is relatively constant despite variations in length of periods themselves and this fact aids farmers in estimating what to expect with regard to dangerously low temperatures during these critical periods.

Research is now under way at the Maryland (coop. USDA), New Jersey, Wisconsin (coop. USDA), and New York (Cornell) stations which will determine the relationships between crop production and the climatological conditions found in the immediate environment of the plants. The influence of macroclimate upon these conditions will also be determined.

FARM FORESTRY RESEARCH

Timber growing is becoming an increasingly important farm enterprise in many parts of the country. Research on the conservation, development, and use of forest resources has been under way at some of the experiment stations for many years. Among such studies, those

that aid the farmer to practice intelligent wood-lot management over the long-time period, to utilize economically timber from his wood lot, and to prevent the spread of tree diseases have practical uses. Following are representative examples of current forestry research under way at State experiment stations.

Thinning Tree Stands in Wood Lots

The Vermont station, after analyzing data collected over the past 10 years, showed that the thinning of partially matured stands in natural stands of white pine resulted in a greater total yield and a higher quality of lumber. The crown type of thinning, that removes larger trees competing with potential final crop trees, yielded a greater volume of saw timber than the volume of cordwood secured from low-type thinning, which smaller competing trees were removed. Removing large, low-grade trees appeared the most promising of three forest-improvement methods being compared by the Mississippi station. This comparison of light, medium, and heavy release cuttings to favor pine and the better hardwoods has been under way for 2 years.

Retarding Spread of Oak Wilt

The continued spread of oak wilt, a serious fungus disease, is becoming an increasing threat to the Nation's oak forests and farm wood lots containing this species. The oak wilt organism can be spread underground from infected oak trees to healthy ones, through natural root grafts. The Wisconsin station has shown that breaking these graft connections with spades or chemicals, if done in time, can prevent the disease from spreading.

Killing Trees With Chemicals

Improved techniques for the chemical killing of trees where competitive growth or an undesirable stand of forest trees becomes a problem were developed by the New Hampshire station. Poison-containing tablets or pads were inserted directly into the cambium tissues by the use of a specially devised hand tool which penetrated and raised a section of the bark. With the use of sodium arsenite-impregnated tabs, white pine and balsam fir trees 2 to 5 inches in diameter and 15 to 30 feet in height were killed in 1 to 3 weeks. Good results were also obtained with ammate on white pine. Single-stemmed trees up to 4 or 5 inches in diameter were killed in 10 to 14 days. Heavily branched trees required more time for complete kill. Where bark loosening as well as killing was the goal, good success was obtained with red maples treated with sodium arsenite tabs.

The material advantages in favor of the new methods are: The treatment is rapid and simple, it reduces the danger to livestock, the expenditure for materials and labor is small, and there is a high degree of successful kill.

HOME ECONOMICS

Feeding, housing, and clothing the family, managing the home, and planning for living within the family income are all matters of concern to the homemaker. Researches within these areas have signifi-

cance, therefore, not only for the production and utilization of agricultural commodities, but also for the improvement of farm family living.

Nutritive Value of Foods

The nutritive value of foods assumes importance whether planning for the Nation's food supply or the family's meals. Research on this problem has merited the attention of the plant breeder, the producer and the distributor, the processor, and the homemaker.

A vitamin-C-destroying factor in tomatoes

Because of the importance of the tomato as a food source of vitamin C, plant breeders have tried to increase the amount of this vitamin in the crop. By crossing common garden varieties with a small, green-colored, vitamin-C-rich product from Peru, the New Hampshire station developed a marketable size tomato with considerably more vitamin C than the standard garden varieties. It was found, however, that the small parent fruit was transmitting an enzyme system capable of destroying the vitamin when the tomato was chopped, sliced, or macerated. Heat treatment, applied before the plant tissue was macerated, inactivated the enzyme so that it was unable to affect the vitamin C. In the future, plant breeders will have to test for this enzyme when considering crosses and the development of new varieties.

Marketing practices affect nutritive value of asparagus

The importance of proper handling procedures in conserving ascorbic acid in asparagus was shown by experiments at the Minnesota station. Freshly gathered asparagus that was rapidly cooled to about 40° F. by immersing in an ice-water bath to simulate hydrocooling, was found to retain twice as much ascorbic acid as a comparable lot placed upright in moist moss and stored overnight in a cool place to simulate the usual growers' practice. Moreover, after blanching, freezing, freezing-storage, and cooking, the hydrocooled samples continued to be about twice as rich in ascorbic acid as the uncooled samples.

"Southern Peas" contribute to good nutrition

The edible varieties of cowpeas, as distinguished from field varieties, constitute an important item of the diet in the South where they are sometimes referred to as Southern peas. Studies at the Texas station show that the maximum ascorbic acid value can be obtained from the cowpeas as eaten, if they are selected at a stage less mature than yellow pods, cooked promptly after harvest—or kept under refrigeration (34° F.) if they must be held—and by hastening the cooking process. Pressure saucepan cooking, in particular, favored the retention of ascorbic acid in the cowpeas. Further investigation showed that cowpeas canned by safe processing methods lost little, if any, niacin and riboflavin, and retained 70 to 80 percent of their pantothenic acid and about 50 percent of their thiamine and ascorbic acid.

Food Preservation and Storage

With the expansion of rural electrification more and more farm families are profiting by the convenience of home-freezer units. Questions concerning their economy and problems associated with

their use are being answered by station researches such as the following:

Quality and economy in freezer-stored meat

Research at the South Dakota station indicated that the home freezer is an efficient means of freezing and storing small quantities of meats. About 4 pounds per cubic foot is the optimum load for quick freezing. The efficiency for freezing and quality preservation is greatly impaired if larger quantities are attempted. The importance of wise choice of wrapping material was also emphasized. Among the materials tested, the ordinary locker paper, waxed on one side only, permitted freezer burn and resulted in cooked meat of inferior quality. A laminated aluminum foil wrap showed unusual ability to control the quality of the meat.

Home canning jars for home and locker freezing

Since glass jars, conveniently available in most farm homes, possess many of the essential characteristics of a satisfactory package for frozen food, the Massachusetts station investigated their suitability and limitations for such use. The studies showed that sugar- and sirup-packed fruits and juices and dry-packed vegetables, meat, and poultry can be successfully frozen in home canning jars under home and locker conditions. The vacuum developed in the jars during freezing and thawing retarded the oxidation of fruits and fruit juices. Head spaces of 0.5 and 1 inch were found satisfactory for pint and quart jars, respectively. No head space was required in freezing dry-pack products. Brine-packed products should not be frozen in such containers since breakage may occur as a result of the expansion of brine during freezing.

Freezing of yeast doughs lowers bread quality

The preparation and freezing of batters and doughs in quantity for storage and later use as needed in baking has seemed to offer possibilities for considerable saving of time for the homemaker. That such a practice is not feasible for yeast bread doughs was demonstrated by experiments at the Montana station. The quality of the bread prepared from the frozen doughs was found to be lower than that from fresh dough, in that the grain was less desirable and a high percentage of the loaves had a compact layer. This was noticeable after only 1 week of frozen storage of the dough at -10° F.; after 8 weeks all samples were of poor quality and storage for this length of time was considered unsatisfactory.

Human Nutrition

Basic and applied research in nutrition continues to provide information of fundamental significance to the problem of improving human well-being through dietary practices. A few of these researches are here discussed.

Weight reduction in young women

Twelve young women, overweight by as much as 20 to 83 pounds, successfully lost weight—19 pounds on an average—during 54 days on a carefully controlled experimental weight-reduction regime at the Nebraska station. It is to be noted especially that this loss of

weight was accomplished on a moderate-cost diet made up of usual foods, including a slice of bread at every meal. The diet was planned to be nutritionally adequate in every respect except that it was restricted to 1,200 calories. Although the subjects, in general, were in equilibrium with respect to calcium and phosphorus, and stored a little nitrogen, the data obtained indicated that during weight reduction the metabolism of calcium and phosphorus of these obese young women was less efficient than in the normal woman of the same age. The possibility of nutritional impairment during weight reduction, even if the diet is optimum, thus becomes an added danger and disadvantage of obesity.

Ascorbic acid requirements of older adolescents

Research at the Oregon station (coop. USDA) has yielded data on which to base recommendations concerning the amount of dietary ascorbic acid required by adolescents. The allowance of 100 mg. for 18-year-old boys and 80 mg. for 16- to 19-year-old girls, tentatively recommended by the National Research Council, did not maintain mean values for blood plasma ascorbic acid as high as the means obtained when the subjects received saturation doses. The concentration of ascorbic acid in the white cell-platelet layer of the blood was the most significant value in detecting marked ascorbic acid deficiency. Serum, plasma, and urinary ascorbic acid determinations were useful, however, in assessing the more nearly adequate or optimal states of nutrition with respect to that vitamin.

Dietary ascorbic acid important for reproduction

To get a better understanding about the effects of ascorbic acid deficiency in man, the Kansas station made a detailed study of the effect of this vitamin deficiency in the guinea pig. This animal was chosen because the guinea pig is one of three animals—man and the monkey are the other two—that must get vitamin C from the diet. One of the significant findings of the study was that ascorbic acid deficiency interfered with and even prevented reproduction. Degenerative changes were observed in the reproductive organs, and such embryos as were formed were retarded and abnormal in development. Male guinea pigs succumbed to the effects of ascorbic acid deficiency sooner than females and young animals succumbed sooner than older ones under similar conditions.

Housing

Modern demands on the farm home point up the need for developing the farmhouse as an integral part of the farmstead. Many farm families plan to build new homes or remodel old ones in an effort to meet more adequately the needs for living. It is essential, therefore, that detailed information be available about the kinds of houses farm families need and want.

North Central research on farm family housing

Approximately 900 families—selected to give a cross-section of the wants and desires of the 2,270,000 farm families living throughout the region—took part in a survey conducted cooperatively by the 12 North Central experiment stations (coop. USDA).

The recently issued report of the findings indicates that the farm families, many of whom hope to build, know the type of house they want. A 5- or 6-room, one-story house with sloping roof and central heating system was the first choice. One or more porches, a spare bedroom, a basement or cellar, a coat closet on the first floor, a separate dining room, and a drive so planned that callers would come to the front door, were other preferences expressed by a large majority. Although one-story houses were most popular, about one-third of the families preferred a two-story house. About three-fourths of these families would like one or more bedrooms downstairs, and the bathroom on the first floor if they had no lavatory. Most families wanted to be able to serve meals in the kitchen, but many of them also wanted a dining room that would accommodate six or more persons.

Baking, food preservation, laundering, and sewing were home activities conducted by most of the farm homemakers, who wanted adequate working space and storage facilities for these tasks. About half the women asked that drying space be provided in the basement for the family laundry, and three-fourths of all the families interviewed needed space for a farm business center—many of them considered a desk adequate. About three-fourths of the families needed facilities for preparing lard in the house, about half of them for preparing eggs for market, and about one-fourth for preparing cream for market. About half of them needed storage space in the house for milk pails, milk strainers, churns, meat saws, and household scales. About one-fourth of the families needed space for storing some seed in the farmhouse.

The shortcomings in the farmhouses in the region, as of 1948, were revealed in the survey; 75 percent lacked bathrooms; 60 percent, running water; 65 percent, basements with finished walls and floors; 30 percent, electricity; and 30 percent lacked an adequate number of bedrooms on the basis of family size and composition.

Home Management

Savings in time and energy expended in household tasks can be accomplished by thoughtful arrangement of work space and storage areas. Improvement in these home management aspects would encourage maximum productivity in the work of family members and would release energy for added productive work.

Work distances in farm kitchens

Since farm homemakers spend one-half of the time they devote to homemaking activities in kitchen work, the New York (Cornell) station sought facts about the kitchen work space and storage areas in 100 farm homes. Observations on the homemakers at work in these kitchens at 5 typical food preparation tasks and at dishwashing, showed that on the average, 70 percent of the food and equipment items needed in these tasks were stored more than arm's length from the place of use. The average storage distance was 8.3 feet, although many of the items might have been stored in easy-to-reach locations. About one-eighth of the items were stored outside the kitchen—in pantry, basement, dining room, cellarway, milk house, or on the porch. Apparently, little consideration had been given in storage of items

to the inconvenience associated with bending and stooping. The structural limitations or possibilities of the kitchen itself had not seemed to influence the arrangement of these kitchens. The families had merely failed to take advantage of the possibilities available to them to reduce the basic distances.

In six differently arranged kitchens, the Washington station made a motion study of the trips required between the various pieces of equipment and the different storage areas in the preparation of a meal. The observations point to the convenience of the U-type kitchen, suggest that range and sink should be not more than 4 to 6 feet apart, that the sink and stacking counter to the right should be near the dining area, and that the mixing unit could be farthest from the dining area, but should be conveniently near the range and the refrigerator. The observations further indicate that the range should be near the dining area to save steps in serving, but that the refrigerator can be farthest from that area because there is little traffic between refrigerator and table.

Family Economics

The level of living of the rural family is related to its cash income and its ability to produce goods at home. Industrialization of the rural area has seemed to offer potentialities for increasing the cash income of the low-income farm family, either by affording a better market for the commodities produced or by offering opportunity for off-farm work.

Rural farm income in industrialized areas in Mississippi

The extent to which rural families profited by industrialization was brought out by a study conducted by the Mississippi station (coop. USDA), comparing the manner of living of rural families in two Mississippi counties, one highly industrialized, the other less industrialized.

On the basis of family living data obtained, the 1,191 rural families interviewed were classified as off-farm, part-farm, and farm, depending on the source of earnings of all members of the family. The distribution of families within these several groups differed in the two counties, 44 percent deriving their living from off-farm work and 15 percent from farm work in the highly industrialized county, where most of the industrial workers were male, as compared with 29 and 37 percent, respectively, in the less industrialized county, where most of those working off the farm were female.

In both counties, however, off-farm and part-farm groups had much higher incomes than the farm group, and consequently purchased more consumer goods and services, and had better housing facilities and equipment. The part-farm group participated somewhat more often in community activities. Families in the farm and part-farm groups benefited by their production of protective foods for home use. Farm families in industrial areas, however, had not been lifted from their low socioeconomic plight by the industrialization of the area.

This investigation has pointed up the need for research to show how off-farm work may best be combined with farm operation for the good of the family, and also to show how families who choose to confine their work to farming can benefit by industrialization of the region. Since this study was made, local interests, through certain marketing and community approaches, have taken steps designed to help families in low-income farm groups.

Textiles and Clothing

Researches such as the following demonstrate the adaptability and economy of agricultural fibers for home furnishings and clothing.

Home-furnishing fabrics from Oregon linen yarns

The superiority of Oregon linen yarns for the weaving of home furnishings fabrics has been demonstrated by the Oregon station through experimental weaving of linen fabrics for different uses. These fabrics, woven for draperies, upholstery, table linens, rugs, curtain materials, grill fronts for radios, screens, etc., have been enthusiastically appraised by textile manufacturers, dealers, and designers. In comparison with other available linen yarns, chiefly imported, the Oregon yarns proved as durable and strong and no more expensive, and offered an additional advantage—greater variety in color, and in yarn size and weight. Results obtained with a new yarn developed by an Oregon mill indicate that it can be used to advantage for drapery, upholstery, and table linens and that its cost is about half the cost for rival imported fabrics. Production of the Oregon linen fabrics on power looms appears feasible. Success of such production as a commercial venture is suggested by the favorable response of outstanding textile manufacturers, dealers, and designers to exhibits of the experimental fabrics. An increasing amount of fiber flax is being grown in the State and the demand for the fiber is increasing.

Cotton poplin makes attractive, durable uniforms

Cotton broadcloth, poplin, suiting, and jean—four materials commonly used for professional garments, such as nurses' uniforms—were studied by the Minnesota station to determine their properties and serviceability. The data obtained showed that the serviceability to be expected from poplin is markedly greater than that to be expected from suiting and jean, which are usually considered to be strong and durable materials. Broadcloth could be rated somewhat above the suiting. Based on current costs and observed and predicted days of wear to be obtained from each, it appears that the selection of poplin instead of suiting could save the cost of one uniform per year and at the same time provide better looking garments.

STATISTICS—PERSONNEL, PUBLICATIONS, INCOME, AND EXPENDITURES

Personnel and Publications

The research personnel of the experiment stations in 1951 included 3,441 staff members devoting full time to station research and 3,773

who divided time between research and teaching or extension work. The total in both categories, 7,214, represented an increase of 271 over the total of 1950. There were also 149 more full-time workers in 1951.

Printed publications of the experiment stations in 1951 included 814 bulletins, circulars, and reports; 4,558 articles in scientific journals; and 339 miscellaneous publications. In addition, 2,435 popular and 1,477 technical reports, bulletins, and circulars were processed by the stations.

Data by individual States relating to personnel and publications are shown in tables 1 and 2.

Income and Expenditures

Appropriations under the authorizations of the Hatch, Adams, and Purnell Acts for use by the experiment stations in 1951 totaled \$4,552,500, each State, Hawaii, and Puerto Rico receiving \$90,000 and Alaska \$52,500. A total of \$2,863,708 was appropriated under the Bankhead-Jones Act of June 29, 1935, with allotments to the individual States, Hawaii, Alaska, and Puerto Rico as shown in table 3. These allotments are made primarily on the basis of rural population adjusted in accordance with the provisions of the Department of Agriculture Organic Act of 1944. The total amount of Federal-grant funds appropriated to this Office under the Hatch, Adams, and Purnell Acts, and title I of the Bankhead-Jones Act, was \$7,416,208.

Under title I, section 9, of the Research and Marketing Act of 1946, \$5,000,000 was appropriated. Of this total \$150,000, authorized by section 9 (c) of the act, was available to the Office of Experiment Stations for administration. Of the remainder \$3,600,000 was allotted to the States, Hawaii, Alaska, and Puerto Rico, under the formulas described in sections 9 (b) (1) and (2); \$1,250,000 was available for allotment to the States for cooperative regional research projects authorized by section 9 (b) (3) and for travel by the Committee of Nine established in accordance with this section. The amounts allotted under sections 9 (b) (1), (2), and (3) are shown in table 3. Also shown are the unexpended balances of allotments for fiscal year 1950, which were available for expenditure during fiscal year 1951.

In addition to the Federal-grant funds enumerated above, the Office received funds from title II of the Research and Marketing Act for allotment to the State agricultural experiment stations for marketing research. Allotments totaling \$299,967.22 were made to the stations during the fiscal year 1951 (table 3).

Non-Federal income of the stations appears in table 4.

Expenditures of Federal-grant funds are shown under object classes by individual experiment stations in tables 5, 6, 7, 8, 9, and 10; expenditures of non-Federal funds are indicated in table 11. The 1951 expenditures of non-Federal funds which include State appropriations, research grants, and income from other sources totaled \$50,972,123.13, as compared with \$45,204,956.85 in 1950. The 1951 non-Federal fund

expenditures by all of the stations approximated \$4.05 for each \$1 of Federal grants. Summaries of expenditures appear in tables 12 and 13.

Expenditures and allotments of funds from title II of the Research and Marketing Act are shown in table 14.

TABLE 1.—*Organization and personnel of the experiment stations for the year ended June 30, 1951*

Station	Date of legislative assent to Hatch Act	Date of organization under Hatch Act	Personnel				Total research workers
			Full-time research	Research and teaching	Research and extension	Research, teaching, and extension	
			Number	Number	Number	Number	Number
Alabama.....	Feb. 27, 1889	Apr. 1, 1888	68	55	1	4	128
Alaska.....	May 2, 1929	May 1, 1931	23	23			23
Arizona.....	Mar. 19, 1889	July 1, 1889	30	41	1		72
Arkansas.....	Mar. 7, 1889	Apr. 2, 1888	39	56	1	1	97
California.....	Mar. 12, 1889	Mar. 13, 1888	142	324			466
Colorado.....	Mar. 25, 1889	Feb. 20, 1888	37	82		4	123
Connecticut: State.....	May 18, 1887	May 18, 1887	68				68
Storrs.....	do	Apr. 1, 1888	35	29	5	5	74
Delaware.....	Apr. 14, 1887	Feb. 21, 1888	16	16	7	4	43
Florida.....	June 7, 1887	Mar. 16, 1888	159	22	7	4	192
Georgia.....	Dec. 24, 1888	Feb. 18, 1888	128	48	1	12	189
Hawaii.....	Mar. 31, 1911	July 1, 1929	47	15	4	1	67
Idaho.....	Jan. 32, 1891	Feb. 26, 1892	27	39		1	67
Illinois.....	May 11, 1887	Mar. 21, 1888	113	80	10	6	209
Indiana.....	Jan. 19, 1889	July 1, 1887	100	89	14	12	215
Iowa.....	Mar. 1, 1888	Feb. 17, 1888	55	132	21	10	218
Kansas.....	Mar. 3, 1887	Feb. 8, 1888	46	161			207
Kentucky.....	Feb. 20, 1888	Apr. 29, 1888	31	31	5	12	153
Louisiana.....	July 12, 1888	Apr. 5, 1887	105	56	1		165
Maine.....	Mar. 16, 1887	Feb. 16, 1888	37	28	2	1	68
Maryland.....	Mar. 6, 1888	Mar. 9, 1888	27	28	10	30	95
Massachusetts.....	Apr. 20, 1887	Mar. 2, 1888	86	18			104
Michigan.....	Apr. 12, 1889	Feb. 26, 1888	96	120	10	8	234
Minnesota.....	Feb. 4, 1889	Jan. 26, 1888	36	158	5	4	203
Mississippi.....	Jan. 31, 1888	Spring, 1888	75	39	1	3	118
Missouri.....	June 11, 1889	Jan. 31, 1888	24	132		4	160
Montana.....	Feb. 16, 1893	July 1, 1893	41	43	1	13	98
Nebraska.....	Mar. 31, 1887	June 14, 1887	70	72		1	143
Nevada.....	Feb. 8, 1889	Dec., 1887	16			2	18
New Hampshire.....	Aug. 4, 1887	Feb. 22, 1888	17	36	3	5	61

New Jersey.....	Mar. 16, 1887	Mar. 5, 1888	66	73	2	2	143
New Mexico.....	Feb. 28, 1889	Nov. 14, 1889	25	29	2	2	58
New York.....	Mar. 30, 1887	Apr. 30, 1888	39	154	14	34	241
Cornell.....	(¹)		68				68
State.....	Mar. 7, 1887	Dec. 5, 1889	122	97		4	213
North Carolina.....							
North Dakota.....	Mar. 8, 1890	Oct. 15, 1890	47	38			85
Ohio.....	Mar. 16, 1887	Apr. 2, 1888	98	59	1	3	161
Oklahoma.....	Oct. 27, 1890	Aug. 14, 1891	67	92	1		160
Oregon.....	Feb. 25, 1889	July 2, 1888	124	80	1	3	208
Pennsylvania.....	June 3, 1887	June 30, 1887		215			215
Puerto Rico.....	Aug. 16, 1923	Nov. 14, 1935	84				84
Rhode Island.....	Mar. 31, 1867	Nov. 3, 1888	19	14	1	6	40
South Carolina.....	Dec. 22, 1887	Jan., 1888	83	21	2	1	107
South Dakota.....	Mar. 11, 1887	Nov. 17, 1887	38	48		1	87
Tennessee.....	Mar. 29, 1887	July 24, 1887	98	44	1	7	150
Texas.....	Apr. 2, 1887	Jan. 25, 1888	210	67	4	14	295
Utah.....	Mar. 8, 1888	Nov. 6, 1889	46	45	1	4	96
Vermont.....	Nov., 1888	Feb. 28, 1888	7	24	4	11	46
Virginia.....	Feb. 29, 1888	June 13, 1888	100	26	3	7	136
Washington.....	Mar. 9, 1891	May 1, 1891	112	69			181
West Virginia.....	Feb. 22, 1889	June 11, 1888	20	58	1	3	82
Wisconsin.....	(²)	July 1, 1887	82	110	4	22	218
Wyoming.....	Jan. 10, 1891	Mar. 27, 1891	25	36		1	62
Total.....			3,441	3,349	152	272	7,214

¹ First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.

² Session of 1887.

TABLE 2.—Publications issued by the agricultural experiment stations during the fiscal year ended June 30, 1951

Station	Printed publications										Processed publications													
	Reports, bulletins, and circulars					Articles in journals					Periodicals					Pamphlets, leaflets, etc.				Reports, bulletins, circulars, etc.				
	Pop.	Tech.	Pages	Copies		Pop.	Tech.	Pages	Copies reprinted		Pop.	Tech.	Pages	Copies		Pop.	Tech.	Pages	Copies		Pop.	Tech.	Pages	Copies
Alabama.....	9	5	356	21,000			48	217	7,500							4		24	27,000		11	5	168	33,500
Alaska.....	7		89	5,000	2			(1)													4		227	880
Arizona.....	9	3	438	38,000			20	130	5,000	4			48	36,000							5		63	2,500
Arkansas.....	1	16	655	58,500			8	37	1,200									208	33,000			3	26	4,500
California.....	9	8	620	230,500			603	14,681			12	20	912	542,234	2	1	3	34,000				29	1,099	(1)
Colorado.....																								
Connecticut.....	9	3	408	59,950	5		38	(1)		2			200	5,500	3		(1)	10,925		46			338	63,566
State.....																								
Storrs.....	9	2	570	48,200	31		58	120	10,590	1			8	12,000		3	58	3,000		5	15	201	7,275	
Delaware.....							24	198	10,300													12	107	18,500
Florida.....		26	702	246,500	105		29	183																
							158	610																
Georgia.....	6	3	330	63,000			12	54		6			12	54,000						10	9	353	52,900	
Hawaii.....	3	4	348	22,453			21	121								9		57	16,400					
Idaho.....	9	2	296	46,500			23	230		4			64	60,000				32	68,000		2		61	2,000
Illinois.....	21	9	878	477,153			85	900				27	184	103,300						2,100		400	22,500	500,000
Indiana.....		25	826	156,000			87	428				1	26	3,300								432	2,010	238,065
Iowa.....	4	9	843	139,500			130	985	39,850	12			196	249,000										
Kansas.....	17	2	932	127,000			87	492							2		8	20,000		2	22	44	243	45,445
Kentucky.....		27	848	110,900	30		57	337	8,226			6					48	19,400		17	44	891	42,575	
Louisiana.....	1	14	618	73,500			89	304				4	32	18,000										
Maine.....		8	343	22,900			12	57							1	4	181	4,350				9	69	2,900
Maryland.....		10	329	28,100			18	61							10		121	500		2	25	182	(1)	
Massachusetts.....		3	196	11,500			64	358	11,050			12	30	5,100										
Michigan.....	18	16	1,700	260,000	42		109	(1)		4			448	10,000								14	259	10,400
Minnesota.....	2	7	308	43,500			158	1,050	3			3	52	49,550			31	22,000		5			126	4,050
Mississippi.....	17	3	624	90,000			15	138		12			96	438,000	17									
Missouri.....	31	21	1,596	116,000			49	(1)		1			6	26,000	1					31	21	1,796	116,600	
Montana.....	6	1	200	44,500	10															3			31	1,375
Nebraska.....	10	4	451	65,000			37	(1)							22		44	44,000		17			231	26,000
Nevada.....	4		277	10,000																				
New Hampshire.....	3	5	178	20,000			6	32												1	3	25	4,000	
New Jersey.....																								
New Mexico.....	4	8	398	54,300			98	686		1	1	1,024	90,000		20		224	28,750		12			104	8,000
New York.....	9		233	36,200			5	14																

[illegible]

Total unknown.

TABLE 3.—Federal funds available to the experiment stations for the year ended June 30, 1951

Station	Hatch, Adams, and Purnell ²	Bankhead- Jones	Federal-grant funds ¹					Total	Contractual Federal funds Research and Marketing, title II			Total Federal funds available
			Research and Marketing, title I						Carry-over from 1950	1951 Allotment	Total	
			Secs. 9 (b) 1 and 9 (b) 2		Sec. 9 (b) 3							
			Carry-over from 1950	1951 Appro- priation	Carry-over from 1950	1951 Appro- priation						
Alabama	\$90,000	\$96,152.81	\$34,049.54	\$118,337.56	\$2,646.92	\$17,622.00	\$358,808.83	\$4,387.54	\$6,000.00	\$10,387.54	\$369,196.37	
Alaska	52,500	2,627.86	11,233.76	20,920.04	813.19	12,114.00	87,281.66				87,281.66	
Arizona	90,000	15,499.36	859.51	31,490.04	12,350.91	20,212.00	150,776.10				150,776.10	
Arkansas	90,000	74,312.76	23,507.21	98,754.70	2,624.30	19,350.00	319,137.58				319,137.58	
California	90,000	95,542.61	2,375.00	91,417.48			301,309.39		8,400.00	8,400.00	309,709.39	
Colorado	90,000	26,055.98	10,072.96	41,742.64	12,112.34	42,375.00	222,358.92				222,358.92	
Connecticut												
State	45,000	13,129.28	6,453.89	18,045.38		1,000.00	83,628.55				83,628.55	
Storrs	45,000	13,129.28	2,572.22	18,045.38	1,198.75	16,200.00	96,145.63	267.78	7,000.00	7,267.78	103,413.41	
Delaware	90,000	6,054.94	9,054.78	24,301.46		1,000.00	130,411.18				130,411.18	
Florida	90,000	40,579.22	9,385.68	50,946.22	2,002.19	12,050.00	204,963.31	7,552.95	8,200.00	15,752.95	220,716.26	
Georgia	90,000	101,476.80	4,325.18	120,955.28	9,915.86	44,688.00	371,361.12	7,236.82	21,700.00	28,936.82	400,297.94	
Hawaii	90,000	10,269.39	8,172.15	28,450.40			136,891.94	3,120.23	12,000.00	15,120.23	152,012.17	
Idaho	90,000	16,589.81	8,958.13	35,604.96	1,930.64	19,500.00	172,583.54				172,583.54	
Illinois	90,000	100,946.87	38,494.20	105,872.66	23,486.16	15,405.08	374,204.97	7,200.00	3,600.00	10,800.00	385,004.97	
Indiana	90,000	73,383.88	9,800.20	87,106.72	22,147.98	48,321.00	330,759.78	5,688.80	24,100.00	29,788.80	360,548.58	
Iowa												
Iowa	90,000	74,752.37		89,887.30	19,373.41	63,020.00	337,033.08	2,032.50	22,500.00	24,532.50	361,565.58	
Kansas	90,000	57,178.54	757.09	67,623.70	778.47	19,350.00	235,687.80	816.47	11,300.00	12,116.47	247,804.27	
Kentucky	90,000	95,122.25	11,053.80	115,404.96	266.62	8,225.00	320,072.63				320,072.63	
Louisiana	90,000	65,919.96	22,780.44	85,178.44	11,017.32	20,050.00	294,946.16				294,946.16	
Maine	90,000	24,124.05	6,485.69	37,979.00		23,850.00	182,438.74	346.39	7,500.00	7,846.39	190,285.13	
Maryland												
Maryland	90,000	35,303.01	3,950.83	46,055.54	960.20	17,765.00	194,034.58	102.15	7,000.00	7,102.15	201,136.73	
Massachusetts	90,000	21,787.39	35,751.10	35,751.10	265.40	13,700.00	161,503.89				161,503.89	
Michigan	90,000	85,827.73	33,867.62	95,112.60	12,099.12	27,068.50	323,975.57	14,355.36	47,500.00	61,855.36	385,830.93	
Minnesota	90,000	66,813.91	13,764.01	88,077.22	7,808.71	31,265.00	322,728.85				322,728.85	
Mississippi	90,000	84,569.98	20,551.31	115,794.68	9,861.80	38,142.00	358,919.77	12,765.40	28,800.00	41,565.40	400,485.17	
Missouri												
Missouri	90,000	89,383.63	3,652.63	106,039.24	53.14	20,850.00	309,978.64		3,400.00	3,400.00	313,378.64	
Montana	90,000	17,871.46	1,535.24	34,513.38	3,939.29	16,711.00	164,590.37				164,590.37	
Nebraska	90,000	44,233.72	3,913.68	57,743.04	649.24	20,100.00	216,639.68		5,000.00	5,000.00	221,639.68	
Nevada	90,000	3,190.40		21,738.58		5,150.00	120,078.98				120,078.98	
New Hampshire	90,000	9,925.30		27,101.98		4,300.00	131,327.28				131,327.28	

New Jersey.....	90,000	36,470.37	2,021.67	42,398.00	5,350.26	24,615.00	200,855.30	1,923.20	8,300.00	10,223.20	211,078.50
New Mexico.....	90,000	16,935.36	10,387.77	34,773.18	810.04	18,800.00	171,686.35				171,686.35
New York:											
Cornell.....	81,000	99,202.17	8,659.52	90,622.73	17,256.40	50,365.00	347,105.82	4,071.10	2,245.00	6,316.10	363,421.92
State.....	9,000	11,022.46	3,290.36	10,069.19	10,375.15		33,352.01	770.97	10,000.00	10,770.97	44,122.98
North Carolina.....	90,000	123,766.51	12,097.32	145,018.08		40,237.50	421,494.56		5,600.00	5,600.00	427,094.56
North Dakota.....	90,000	28,147.42	4,384.91	44,318.38	2,711.65	5,100.91	174,663.27				174,663.27
Ohio.....	90,000	109,337.26	98,029.25	114,946.30	3,466.93	22,714.92	438,494.86	3,837.24	7,374.24	11,211.48	449,706.34
Oklahoma.....	90,000	78,367.16	10,873.51	89,931.48	1,567.27	17,150.00	287,891.42	1,729.60		1,729.60	289,621.02
Oregon.....	90,000	26,588.72	3,965.25	42,547.16	5,024.65	37,900.00	206,025.78	1,059.90	2,500.00	3,559.90	209,585.68
Pennsylvania.....	90,000	157,876.48	42,639.10	130,364.04	10,521.39	35,690.00	467,091.01				467,091.01
Puerto Rico.....	90,000	62,082.14	14,250.59	92,283.74		3,500.00	262,116.47	8,373.54	3,200.00	11,573.54	273,690.01
Rhode Island.....	90,000	2,857.19	3,667.56	21,643.08	1,563.02	24,085.00	143,815.85				143,815.85
South Carolina.....	90,000	69,224.19	17,631.88	88,855.84	3,376.30	26,530.50	295,618.71				295,618.71
South Dakota.....	90,000	27,733.01	12,976.33	42,917.76	2,998.67	15,300.00	191,925.77				191,925.77
Tennessee.....	90,000	89,992.09	12,320.71	113,618.52	5,478.81	28,503.00	339,913.13	474.87	10,000.00	10,474.87	350,388.00
Texas.....	90,000	173,212.81	1,633.95	185,536.50	1,076.04	61,140.00	512,599.30	13,417.10	13,866.89	27,283.99	539,883.29
Utah.....	90,000	12,170.15	1,012.45	29,309.12	11,382.33	79,650.00	223,524.05				223,524.05
Vermont.....	90,000	12,078.01	4,397.56	29,190.60	1,156.88	5,865.00	142,688.05				142,688.05
Virginia.....	90,000	82,941.86	24,442.46	98,338.98	3,000.00	12,375.00	311,098.30				311,098.30
Washington.....	90,000	38,797.09	10,701.49	51,558.50	5,935.37	35,350.00	232,342.45	8,156.72	2,881.09	11,037.81	243,380.26
West Virginia.....	90,000	65,169.05	33,244.60	71,672.89	9,587.09	31,915.00	301,588.54		2,500.00	2,500.00	304,088.54
Wisconsin.....	90,000	70,152.59	1,818.31	88,024.64	4,376.34	52,729.00	307,100.88	1,956.88	7,500.00	9,456.88	316,557.76
Wyoming.....	90,000	7,829.36	5,783.53	26,069.34	979.18	14,950.00	145,611.41				145,611.41
Total.....	4,552,500	2,863,708.00	646,808.83	3,599,999.84	266,315.73	1,243,849.41	13,173,181.81	111,643.51	299,967.22	411,610.73	13,584,792.54

1 Includes unexpended balances from the previous year as follows:

Hatch—Connecticut (State), \$38.20; New York (Cornell), \$0.02; New York (State), \$8.73.
 Adams—Delaware, \$303.63; New York (State), \$6.25.
 Purnell—Arkansas, \$224.60; Connecticut (State), \$40.64; Connecticut (Storrs), \$9.11; Hawaii, \$48.67; New York (Cornell), \$172.20; New York (State), \$1.43; Puerto Rico, \$9.46; Texas, \$0.05; Vermont, \$97.31.
 Bankhead-Jones—Arkansas, \$30; Connecticut (State), \$44.10; Connecticut (Storrs), \$343.27; Indiana, \$15.02; Maryland, \$5.27; New York (Cornell), \$0.32; New York (State), \$26.51; Puerto Rico, \$70.32; Texas, \$0.39; Vermont, \$5.77.
 Hatch, \$15,000 for each State, Alaska, Hawaii, and Puerto Rico. Adams, \$15,000 for each State, Hawaii, and Puerto Rico; \$7,500 for Alaska. Purnell, \$60,000 for each State, Hawaii, and Puerto Rico; \$30,000 for Alaska.

TABLE 4.—Non-Federal funds available to the experiment stations for the year ended June 30, 1951

Station	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Balance from previous year	Total
Alabama.....	\$540,697.35	\$63,071.20	-----	\$511,600.25	\$3,217.45	\$342,328.89	\$1,460,915.14
Alaska.....	75,000.00	-----	-----	39,999.33	-----	26,299.08	141,298.41
Arizona.....	297,907.00	33,803.97	-----	39,729.77	-----	-----	371,440.74
Arkansas.....	344,550.00	46,307.67	-----	235,787.58	-----	71,672.33	698,317.58
California.....	4,479,815.16	176,536.54	-----	122,299.65	-----	200,499.17	4,979,150.52
Colorado.....	276,428.57	107,084.83	-----	119,112.83	4,588.65	142,666.40	649,881.28
Connecticut.....	-----	-----	-----	-----	-----	-----	-----
State.....	354,098.57	22,910.00	-----	-----	-----	-----	377,008.57
Storrs.....	357,811.77	73,790.43	-----	-----	-----	-----	431,602.20
Delaware.....	107,693.07	-----	-----	99,798.04	22,748.48	35,803.47	266,043.06
Florida.....	2,272,271.00	127,877.35	-----	410,861.81	1,556.51	483,346.31	3,297,912.98
Georgia.....	152,000.00	36,009.08	-----	173,357.87	-----	75,492.65	436,859.60
Hawaii.....	459,034.64	8,048.22	-----	43,926.23	151,984.57	5,977.38	668,971.04
Idaho.....	380,019.23	9,767.00	-----	101,011.85	-----	154,304.97	645,103.05
Illinois.....	1,352,292.18	143,010.46	-----	365,262.66	-----	-----	1,860,565.30
Indiana.....	902,000.00	196,406.06	\$196,726.72	549,792.67	3,420.03	686,647.88	2,534,993.36
Iowa.....	825,000.00	274,925.28	-----	566,955.25	-----	280,174.35	1,947,054.88
Kansas.....	330,242.49	-----	-----	369,284.36	60,502.35	855,441.62	1,555,470.92
Kentucky.....	262,256.78	-----	209,564.21	108,757.08	53,235.58	-----	633,813.65
Louisiana.....	1,147,441.30	21,285.92	-----	-----	47,073.46	-----	1,213,800.08
Maine.....	208,238.61	-----	-----	28,341.17	10,480.53	32,345.71	279,406.02
Maryland.....	295,862.00	42,481.00	-----	108,185.99	-----	88,796.10	535,325.09
Massachusetts.....	432,177.59	28,150.00	-----	-----	23,858.53	484,186.12	947,212.24
Michigan.....	998,741.00	290,623.49	-----	-----	1,397,296.86	107,932.37	2,393,363.72
Minnesota.....	1,218,096.01	85,300.70	8,500.79	384,088.11	-----	-----	1,695,985.61
Mississippi.....	783,817.28	53,623.68	-----	488,986.89	23,141.98	111,631.64	1,461,201.47
Missouri.....	198,375.00	70,543.05	194,517.64	143,513.68	-----	195,087.49	802,036.86
Montana.....	383,395.00	7,815.00	-----	344,794.79	-----	202,740.15	938,744.94
Nebraska.....	452,877.53	-----	-----	606,688.87	-----	60,636.67	1,120,223.07
Nevada.....	32,628.34	-----	-----	43,378.50	-----	20,213.64	96,220.48
New Hampshire.....	48,345.70	-----	-----	4,250.11	-----	4,210.54	56,806.35
New Jersey.....	766,562.06	339,182.39	-----	-----	-----	3,670.77	1,109,415.22
New Mexico.....	174,600.00	-----	-----	64,989.78	-----	68,362.27	307,952.05
New York.....	-----	-----	-----	-----	7,696.40	-----	7,696.40
Cornell.....	2,103,420.24	-----	-----	359,556.04	-----	-----	2,470,076.28
State.....	795,306.45	-----	-----	20,600.89	-----	-----	815,907.34
North Carolina.....	1,103,153.57	-----	-----	-----	251,926.47	-----	1,355,080.04

North Dakota.....	514, 621. 22	14, 312. 43	-----	138, 487. 78	-----	97, 483. 17	764, 904. 60
Ohio.....	1, 110, 255. 77	-----	-----	225, 153. 50	-----	687, 715. 75	2, 023, 125. 02
Oklahoma.....	713, 303. 00	53, 804. 99	-----	277, 428. 09	26, 904. 80	164, 625. 07	1, 236, 065. 95
Oregon.....	1, 126, 438. 83	69, 958. 51	185, 747. 47	155, 769. 45	-----	-----	1, 537, 914. 26
Pennsylvania.....	466, 784. 83	138, 370. 87	-----	143, 804. 42	253, 338. 77	75, 929. 75	1, 078, 228. 24
Puerto Rico.....	490, 250. 00	-----	-----	-----	184, 245. 42	216, 869. 37	891, 364. 79
Rhode Island.....	60, 428. 62	14, 549. 29	-----	20, 337. 62	-----	31, 525. 48	126, 841. 01
South Carolina.....	494, 375. 77	11, 641. 40	-----	85, 505. 24	-----	38, 263. 88	620, 786. 29
South Dakota.....	166, 906. 00	7, 392. 25	-----	147, 617. 30	-----	30, 578. 02	352, 493. 57
Tennessee.....	303, 465. 91	82, 405. 16	-----	242, 805. 97	-----	-----	628, 677. 04
Texas.....	1, 006, 549. 00	177, 486. 53	56, 031. 30	998, 932. 10	94, 272. 65	827, 134. 29	3, 160, 405. 87
Utah.....	290, 000. 00	113, 839. 89	-----	68, 814. 27	27, 918. 60	53, 493. 28	551, 066. 04
Vermont.....	52, 859. 23	-----	-----	4, 576. 09	19, 319. 93	16, 755. 49	93, 510. 74
Virginia.....	681, 605. 23	-----	-----	76, 684. 84	-----	31, 548. 22	789, 838. 29
Washington.....	1, 426, 788. 80	121, 201. 66	-----	262, 019. 57	-----	-----	1, 810, 010. 03
West Virginia.....	304, 196. 00	3, 000. 00	-----	141, 897. 57	730. 00	127, 908. 19	577, 731. 76
Wisconsin.....	1, 147, 024. 00	483, 550. 00	-----	353, 111. 00	-----	-----	1, 983, 685. 00
Wyoming.....	1, 264, 630. 32	13, 000. 00	-----	105, 752. 99	-----	80, 058. 57	463, 441. 88
Total.....	35, 532, 638. 02	3, 563, 066. 30	851, 088. 13	9, 903, 609. 45	1, 248, 302. 63	6, 002, 019. 71	57, 100, 724. 24

TABLE 5.—Expenditures and appropriations under the Hatch Act (Mar. 2, 1887) for the year ended June 30, 1951

Station	Expenditures											Unex- pended	Appro- priation
	Personal services	Travel	Trans- porta- tion of things	Communi- cation service	Rents and utility services	Printing and repro- duction	Other contra- ctual services	Supplies and ma- terials	Equip- ment	Lands and struc- tures (con- tractual)	Contrib- utions to retire- ment	Taxes and assess- ments	Total expendi- tures
Alabama.....	\$13,994.02	\$92.10	\$64.90	\$12.56	\$76.52	-----	\$80.45	\$551.99	\$127.46	-----	-----	-----	\$15,000.00
Alaska.....	12,859.66	19.54	-----	-----	-----	\$682.00	59.12	748.34	631.34	-----	-----	-----	15,000.00
Arizona.....	13,808.54	226.89	-----	-----	-----	427.40	-----	462.34	14.83	-----	-----	-----	15,000.00
Arkansas.....	10,712.15	-----	-----	-----	70.00	2,285.04	133.38	1,423.05	107.50	-----	\$238.88	-----	15,000.00
California.....	15,000.00	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	15,000.00
Colorado.....	9,452.03	1,877.08	-----	31.86	-----	321.15	2,570.40	159.35	161.72	-----	426.41	-----	15,000.00
Connecticut: State.....	7,500.00	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	7,500.00
Storrs.....	5,033.79	232.74	-----	-----	-----	54.05	-----	60.34	2,119.02	-----	-----	-----	7,500.00
Delaware.....	10,988.44	351.57	10.79	680.42	6.00	496.00	30.30	1,752.51	538.90	-----	-----	-----	14,824.93
Florida.....	15,000.00	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	15,000.00
Georgia.....	11,544.35	-----	2.40	-----	-----	315.78	45.05	1,803.09	1,289.33	-----	-----	-----	15,000.00
Hawaii.....	13,436.49	-----	1.50	-----	-----	-----	97	199.39	1,361.65	-----	-----	-----	15,000.00
Illinois.....	9,045.50	2,960.97	86.37	425.44	89.46	896.76	75.38	1,089.44	330.68	-----	527.58	-----	15,000.00
Indiana.....	13,185.46	-----	13.31	-----	-----	1,191.05	82.60	-----	-----	-----	-----	-----	15,000.00
Iowa.....	10,524.47	-----	153.33	26.26	-----	4,295.94	-----	-----	-----	-----	-----	-----	15,000.00
Kansas.....	13,614.49	485.89	-----	32.27	67.61	-----	151.64	481.35	166.75	-----	-----	-----	15,000.00
Kentucky.....	155.11	-----	6.13	-----	-----	-----	-----	63.80	-----	-----	-----	\$90.81	15,000.00
Louisiana.....	13,810.07	390.17	-----	127.07	-----	270.40	42.30	67.49	322.50	-----	-----	-----	15,000.00
Maine.....	12,416.43	285.95	58.16	218.46	238.04	136.82	5.00	1,494.30	146.84	-----	-----	-----	15,000.00
Maryland.....	6,501.42	4,153.73	-----	34.05	17.97	908.59	119.76	2,230.95	806.20	\$166.07	-----	-----	14,998.74
Massachusetts.....	10,420.52	702.04	-----	-----	-----	8,050.00	379.20	1,141.03	2,357.21	-----	-----	-----	15,000.00
Michigan.....	6,950.00	-----	-----	-----	-----	-----	53.75	1,130.37	228.00	-----	259.14	-----	15,000.00
Minnesota.....	12,718.67	610.07	-----	-----	20.69	3.00	323.00	1,394.49	1,140.14	-----	-----	-----	15,000.00
Mississippi.....	11,271.91	358.91	7.84	480.02	-----	-----	-----	-----	-----	-----	-----	-----	15,000.00
Missouri.....	12,732.89	105.96	14.40	-----	-----	16.25	28.65	1,120.54	282.99	473.00	231.57	-----	15,000.00
Montana.....	13,107.46	574.54	8.19	49.69	-----	-----	56.64	473.07	714.16	-----	-----	-----	15,000.00
Nebraska.....	15,000.00	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	15,000.00
Nevada.....	11,508.75	514.90	224.63	297.26	91.25	-----	25.25	1,103.11	1,234.82	-----	-----	-----	15,000.00
New Hampshire.....	12,540.02	-----	-----	577.86	1,100.00	150.20	43.75	50.56	337.61	-----	-----	-----	15,000.00
New Jersey.....	12,217.75	283.93	-----	50.00	-----	-----	734.96	297.89	1,415.47	-----	-----	-----	15,000.00
New Mexico.....	13,880.88	260.55	22.88	33.92	263.30	-----	246.46	127.01	165.00	-----	-----	-----	15,000.00

TABLE 6.—Expenditures and appropriations under the Adams Act (Mar. 16, 1906)¹ for the year ended June 30, 1951

Station	Expenditures										Unex- pended	Appro- priations
	Personal services	Travel	Transpor- tation of things	Communi- cation service	Rents and utility services	Other contract- ual serv- ices	Supplies and mat- erials	Equip- ment	Lands and structures (contract- ual)	Taxes and assess- ments	Total expendi- tures	
Alabama.....	\$10,442.69	\$288.91	\$22.28	\$16.90	\$777.29	\$58.45	\$1,307.04	\$1,386.44	\$700.00		\$15,000.00	\$15,000
Alaska.....	6,961.54					10.20	183.55	344.71			7,500.00	7,500
Arizona.....	11,313.04	1,465.88	108.67	95.65	21.41	279.12	1,475.27	130.57	110.39		15,000.00	15,000
Arkansas.....	11,439.90	557.81			67.50	9.68	855.75	1,693.52		\$375.84	15,000.00	15,000
California.....	15,000.00										15,000.00	15,000
Colorado.....	11,887.98	148.90	91.05	6.25	245.01	171.70	2,141.41	285.49		322.21	15,000.00	15,000
Connecticut: State.....	7,500.00										7,500.00	7,500
Storrs.....	7,500.00										7,500.00	7,500
Delaware.....	12,990.11	318.32	10.02	.81	55.44	171.34	1,151.08	150.20			14,847.92	15,000
Florida.....	15,000.00										15,000.00	15,000
Georgia.....	12,889.56	56.00	13.28			93.41	1,947.75				15,000.00	15,000
Hawaii.....	14,153.27	3.70						843.03			15,000.00	15,000
Idaho.....	13,449.83	236.48	9.22			36.34	1,108.57	159.56			15,000.00	15,000
Illinois.....	13,362.62		31.46			101.86	509.68	379.44		614.94	15,000.00	15,000
Indiana.....	13,308.03						1,491.97				15,000.00	15,000
Iowa.....	15,000.00										15,000.00	15,000
Kansas.....	12,178.70					35.39	2,207.35	578.56			15,000.00	15,000
Kentucky.....	15,000.00										15,000.00	15,000
Louisiana.....	12,380.65	405.38	3.58	2.05	99.51	109.44	1,502.71	496.08			15,000.00	15,000
Maine.....	13,694.84	78.72	3.33	3.25		104.52	1,103.09	12.25			15,000.00	15,000
Maryland.....	13,718.00	80.81					608.25	592.94			15,000.00	15,000
Massachusetts.....	15,000.00										15,000.00	15,000
Michigan.....	15,000.00										15,000.00	15,000
Minnesota.....	13,367.67		1.49			15.80	772.51	536.21			15,000.00	15,000
Mississippi.....	12,351.18	193.73	8.57	21.43	265.03	162.98	1,673.75	181.37	141.76		15,000.00	15,000
Missouri.....	11,844.30										15,000.00	15,000
Montana.....	13,619.99	413.43	20.00	7.42	19.70	697.80	1,653.34	558.51		206.35	15,000.00	15,000
Nebraska.....	15,000.00					249.44	674.63	35.09			15,000.00	15,000
Nevada.....	11,834.53	57.75		.10	18.13	11.15	1,896.18	1,182.16			15,000.00	15,000
New Hampshire.....	13,730.35	34.08	37.04	40.50		28.85	601.40	527.78			15,000.00	15,000
New Jersey.....	13,488.00	80.42	4.67			74.80	649.11	703.00			15,000.00	15,000
New Mexico.....	12,275.99	17.09	12.41	22.65	241.62	486.18	1,424.42	519.64			15,000.00	15,000

TABLE 7.—Expenditures and appropriations under the Purnell Act (Feb. 24, 1925) ¹ for the year ended June 30, 1951

Station	Expenditures												Unex- pended	Appro- priation
	Personal services	Travel	Transporta- tion of things	Communi- cation service	Rents and utility services	Printing and reproduc- tion	Other contract- ual serv- ices	Supplies and ma- terials	Equip- ment	Lands and struc- tures (contract- ual)	Contribu- tions to retire- ment	Taxes and as- sess- ments		
Alabama.....	\$48,388.13	\$631.84	\$76.54	\$203.91	\$1,892.16	\$1,130.51	\$894.21	\$3,758.65	\$2,824.05	\$400.00			\$60,000.00	
Alaska.....	17,490.04	137.88	51.71		50.00	127.55	59.73	2,821.22	9,012.96	248.91			30,000.00	
Arizona.....	42,521.59	3,056.36	257.78	192.21	362.74	752.00	4,062.15	9,157.86	2,248.20	389.11			60,000.00	
Arkansas.....	45,647.18	1,141.82	93.24		884.93	880.08	1,508.79	5,074.47	3,490.24		\$1,279.25		60,000.00	
California.....	60,000.00												60,000.00	
Colorado.....	47,725.24	2,592.48	30.97	157.82	448.26	311.21	431.88	4,208.43	2,131.63		1,962.08		60,000.00	
Connecticut: State.....	25,302.50	310.86	30.42			711.18	425.35	772.79	2,446.90				30,000.00	
Storrs.....	26,073.55	718.32					10.50	468.66	2,728.18				29,999.21	
Delaware.....	48,985.05	2,375.54	37.36	2.96	83.21	4.35	742.31	5,978.47	1,785.21				59,994.46	
Florida.....	60,000.00												60,000.00	
Georgia.....	52,973.74	550.43	26.05		9.45	27.56	319.17	6,074.26	19.34				60,000.00	
Hawaii.....	52,173.55	36.32				632.00	4,600.00	616.85	1,941.28				60,000.00	
Idaho.....	39,809.34	2,343.81	94.21	18.74			252.62	14,290.38	3,190.90				60,000.00	
Illinois.....	52,610.78	1,919.91				317.23	319.64	3,273.61	184.54		1,374.29		60,000.00	
Indiana.....	53,370.90	1,142.54	43.78	121.95			383.15	4,937.68					60,000.00	
Iowa.....	60,000.00												60,000.00	
Kansas.....	55,819.36	507.19		2.38	115.28	65.40	169.23	2,776.05	545.11				60,000.00	
Kentucky.....	53,391.97	1,687.27	55.94	41.25		515.83	53.18	2,707.81	1,261.59			\$285.16	60,000.00	
Louisiana.....	48,174.75	1,861.40	127.20	102.53	489.90	825.90	1,122.21	4,636.58	2,659.53				60,000.00	
Maine.....	45,584.88	3,489.47	55.31	56.44	1,046.28	599.90	746.96	7,823.04	597.72				60,000.00	
Maryland.....	50,105.54	604.91	4.82	74.52	16.09	.75	458.52	6,057.15	2,430.20	247.50			60,000.00	
Massachusetts.....	53,834.11	943.32						3,286.50	1,936.07				60,000.00	
Michigan.....	57,000.00								3,000.00				60,000.00	
Minnesota.....	49,440.63	1,588.90	165.79	69.00		318.40	1,062.98	2,686.78	4,003.36		664.16		60,000.00	
Mississippi.....	45,753.32	1,516.52	143.77	235.21	543.82	1,368.16	774.63	6,997.80	2,666.77				60,000.00	
Missouri.....	46,277.46	1,900.43	178.37	18.43	103.00	17.91	891.45	8,633.23	1,103.49		876.23		60,000.00	
Montana.....	52,832.75	1,508.54	10.80	81.99	80.63	48.50	940.54	3,158.14	1,338.11				60,000.00	
Nebraska.....	54,429.26	351.23			138.05		181.71	3,184.50	1,715.25				60,000.00	
Nevada.....	38,034.34	499.70	49.61	428.57	1,001.86	332.86	786.65	11,370.63	7,182.52	313.26			60,000.00	

New Hampshire.....	49,802.61	1,498.22	58.13	41.23	198.00	24.00	1,279.11	4,388.88	2,779.82	60,000.00	60,000.00	60,000.00
New Jersey.....	50,059.52	1,056.00	145.71	55.38	441.00	30.53	457.03	6,198.57	1,555.66	60,000.00	60,000.00	60,000.00
New Mexico.....	46,784.02	1,810.47	55.59	41.84	2,156.80	---	951.96	4,504.26	1,534.46	60,000.00	60,000.00	60,000.00
New York.....	49,765.75	666.48	7.22	7.20	---	24.85	689.30	2,384.34	454.70	53,999.84	.16	54,000.00
Cornell.....	5,046.16	---	---	---	---	---	51.78	289.22	612.84	6,000.00	---	6,000.00
State.....	47,661.11	3,155.82	29.44	193.29	---	111.75	352.97	5,876.10	2,619.52	60,000.00	---	60,000.00
North Carolina.....	55,552.04	1,001.73	---	10.92	47.76	725.00	118.28	302.90	228.42	60,000.00	---	60,000.00
Ohio.....	50,766.02	2,354.42	157.70	11.91	15.00	20.00	235.46	4,046.62	2,392.87	60,000.00	---	60,000.00
Oklahoma.....	40,110.13	779.59	19.30	---	350.00	4.12	1,214.22	14,834.56	2,688.08	60,000.00	---	60,000.00
Oregon.....	54,618.77	1,023.29	104.92	132.35	---	68.47	91.27	2,385.62	1,575.31	60,000.00	---	60,000.00
Pennsylvania.....	38,560.92	1,543.93	31.75	159.94	---	108.83	279.62	13,904.70	5,410.31	60,000.00	---	60,000.00
Puerto Rico.....	36,368.30	2,780.10	29.76	---	---	50.00	617.19	6,989.88	13,164.77	60,000.00	---	60,000.00
Rhode Island.....	52,887.35	211.51	90.04	---	3.10	300.00	17.25	5,083.71	1,707.04	60,000.00	---	60,000.00
South Carolina.....	50,579.89	862.94	4.28	463.11	182.61	240.54	834.20	2,449.40	4,383.03	60,000.00	---	60,000.00
South Dakota.....	39,271.47	1,313.10	145.71	34.61	255.75	1,813.00	740.29	13,239.32	3,186.75	60,000.00	---	60,000.00
Tennessee.....	57,924.42	---	59.23	4.35	35.83	---	43.91	1,703.86	228.40	60,000.00	---	60,000.00
Texas.....	42,565.86	458.58	12.91	32.27	668.91	365.27	4,195.02	5,008.43	5,432.65	59,999.95	.05	60,000.00
Utah.....	52,310.29	2,577.90	31.04	---	12.50	---	132.27	1,492.07	3,443.93	60,000.00	---	60,000.00
Vermont.....	45,675.00	2,257.11	44.80	41.15	159.98	3,670.45	656.12	4,298.67	1,981.11	60,000.00	---	60,000.00
Virginia.....	56,013.69	941.37	---	---	---	770.00	307.24	1,328.66	1,639.04	60,000.00	---	60,000.00
Washington.....	50,940.94	658.20	226.77	35.69	---	22.65	268.74	5,272.93	2,574.08	60,000.00	---	60,000.00
West Virginia.....	49,819.00	287.62	---	---	362.40	11.50	16.46	4,810.45	4,692.57	60,000.00	---	60,000.00
Wisconsin.....	58,787.18	82.67	---	---	---	807.23	41.64	67.28	214.00	60,000.00	---	60,000.00
Wyoming.....	59,907.99	92.01	---	---	---	---	---	---	---	60,000.00	---	60,000.00
Total.....	2,527,228.99	60,760.65	2,787.97	3,073.15	12,155.30	18,155.47	31,588.89	235,071.97	126,042.51	3,029,983.46	6.54	3,030,000.00

1 Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto Rico by act of Mar. 4, 1931.

TABLE 8.—Expenditures and appropriations under the Bankhead-Jones Act (June 29, 1935) for the year ended June 30, 1951

Station	Expenditures											Unex- pended	Appro- priation
	Personal services	Travel	Trans- portation of things	Communi- cation service	Rents and utility services	Printing and repro- duction	Other contrac- tual services	Supplies and materials	Equip- ment	Lands and struc- tures (contrac- tual)	Contribu- tions to retire- ment	Taxes and assess- ments	Total expendi- tures
Alabama.....	\$73,833.07	\$2,107.91	\$146.80	\$105.04	\$745.44	\$290.00	\$817.05	\$13,624.13	\$3,120.66	\$1,362.71			\$96,152.81
Alaska.....	2,216.20	7.49					9.00	140.28	254.89				2,627.86
Arizona.....	12,621.43	908.18	19.90	53.15	43.86	2.00	686.03	813.07	249.93	101.79			15,499.36
Arkansas.....	52,625.95	2,640.17			579.93	3,473.95	646.21	4,448.45	8,409.88		\$1,488.22		74,312.76
California.....	95,542.61												95,542.61
Colorado.....	21,044.45	387.39	33.51	29.73	695.22	48.81	127.35	1,521.59	1,337.40		830.53		26,055.98
Connecticut: State.....	8,514.50	191.43				59.86	161.78	1,628.86	1,240.61	1,284.00			13,081.04
Delaware.....	8,760.00							4,342.75	25.87				13,129.28
Florida.....	2,952.27	14.14					28.00	2,633.17	427.36				6,054.94
Georgia.....	34,447.93	275.60	124.01		27.00		11.39	3,556.89	2,136.40				40,579.22
Hawaii.....	74,432.17	529.63	110.20	67.30	186.39	36.50	819.01	22,369.16	2,926.44				101,476.80
Idaho.....	8,842.20	5.23						888.76	583.20				10,269.39
Illinois.....	13,547.54	697.11	1.44	70.84	60.48	14.19	287.62	502.40	1,402.94	5.25			16,589.81
Indiana.....	86,101.95	2,492.66	34.59	24.62	157.12	725.71	517.12	4,180.26	3,590.66		3,279.40		100,946.87
Iowa.....	63,157.36	657.01	88.96	119.93	14.50		23.76	5,640.01	1,082.35				73,383.88
Kansas.....	74,752.37												74,752.37
Kentucky.....	46,006.40	864.58	53.61	321.76	100.22		196.01	6,740.54	217.18				57,178.54
Louisiana.....	86,507.18	1,207.45	53.11	38.53		779.46	137.13	5,433.07	547.20			\$135.89	93,122.25
Maine.....	48,600.75	2,541.47	30.57	11.55	131.54	1,958.85	1,406.50	7,379.10	3,254.42	709.77			63,919.96
Maryland.....	20,249.48	771.23	11.60			222.47	266.42	2,229.62	230.14				24,124.05
Massachusetts.....	24,085.98	391.26	4.12	96.81	80.40	2.48	977.24	8,041.49	1,623.23				35,303.01
Michigan.....	21,802.37							288.02					21,787.39
Minnesota.....	77,927.44		234.65				6.00	4,768.14	2,891.50				85,827.73
Mississippi.....	47,038.95	1,965.08	249.17	156.85	4.10	1,245.66	1,109.47	9,002.82	5,624.25		417.56		66,813.91
Missouri.....	66,067.58	1,366.25	457.49	934.35	1,103.05	950.62	795.33	9,467.67	1,943.24	1,484.40			84,569.98
Montana.....	65,130.82	1,378.54	170.70	360.00	520.96	143.92	3,151.58	14,016.28	2,993.66	141.51	1,375.66		89,383.63
Nebraska.....	17,517.18	18.78					7.32	328.18	625.97				17,871.46
Nevada.....	41,924.38	644.03	37.10			397.65	53.69	550.25	625.97				44,283.72
New Hampshire.....	2,394.08	59.03	17.91					109.75	3,190.40	105.00			3,190.40
	9,105.23	98.28	6.01	.35			16.80	259.85	438.78				9,925.30

New Jersey.....	28,740.66	625.80	6.03	302.67	25.38	464.05	4,162.14	2,143.64	36,470.37	---	36,470.37
New Mexico.....	11,179.99	15.00	---	---	---	150.42	4,650.25	939.70	16,935.36	---	16,935.36
New York:											
Cornell.....	63,488.50	1,964.75	38.45	2,182.60	4.60	3,535.55	15,911.00	11,929.29	99,201.63	54	99,202.17
State.....	9,228.51	3,684.29	282.30	209.88	68.02	23.00	1,428.88	1,428.88	10,991.73	30.73	11,022.46
North Carolina.....	99,416.83	---	---	---	---	3,394.07	11,027.43	5,368.07	123,766.51	---	123,766.51
North Dakota.....	26,580.59	136.93	14.98	25.84	---	---	432.66	63.00	28,147.42	---	28,147.42
Ohio.....	94,698.99	1,136.03	13.09	11.90	2,050.12	179.24	5,679.15	5,508.74	109,337.26	---	109,337.26
Oklahoma.....	53,854.96	1,407.22	12.29	75.10	12.75	2,392.42	14,799.09	5,058.33	78,367.16	---	78,367.16
Oregon.....	23,015.07	799.26	7.54	28.75	---	73.09	1,131.87	1,533.14	26,588.72	---	26,588.72
Pennsylvania.....	115,665.15	3,963.04	33.14	4.64	2,343.07	909.58	23,764.94	5,910.16	157,876.48	---	157,876.48
Puerto Rico.....	45,786.65	738.00	23.54	---	---	58.95	12,626.65	2,779.92	62,082.14	---	62,082.14
Rhode Island.....	2,351.51	---	39.96	68.43	7.40	169.00	289.32	---	2,857.19	---	2,857.19
South Carolina.....	57,603.80	370.56	112.94	612.84	15.79	730.07	8,084.00	---	69,224.19	---	69,224.19
South Dakota.....	18,195.85	525.27	55.66	4.85	431.08	245.88	7,090.40	1,254.02	27,733.01	---	27,733.01
Tennessee.....	78,254.28	1,268.72	32.69	144.25	8.00	311.41	7,004.81	1,725.00	89,992.09	---	89,992.09
Texas.....	134,892.18	2,733.31	142.06	217.54	1,138.10	10,350.73	12,531.06	843.10	173,212.42	.39	173,212.81
Utah.....	11,619.69	193.27	1.10	---	---	25.25	185.70	142.96	12,170.15	---	12,170.15
Vermont.....	9,275.00	206.32	1.70	131.70	---	237.61	977.08	897.24	12,078.01	---	12,078.01
Virginia.....	79,387.28	459.20	10.95	---	120.00	257.96	1,911.06	795.41	82,941.86	---	82,941.86
Washington.....	29,451.52	358.81	115.15	1.70	---	569.81	4,396.00	3,780.23	38,673.22	---	38,673.22
West Virginia.....	54,440.80	1,822.69	2.08	337.31	1,648.24	87.85	4,433.61	2,396.47	65,169.05	---	65,169.05
Wisconsin.....	58,937.36	582.35	113.49	---	---	147.14	7,657.95	2,714.30	70,152.59	---	70,152.59
Wyoming.....	6,675.00	340.71	---	---	---	295.65	---	518.00	7,829.36	---	7,829.36
Total.....	2,325,189.99	45,528.00	2,957.65	9,402.35	18,224.68	36,570.89	284,134.72	116,554.89	2,863,593.57	204.43	2,863,798.00

TABLE 9.—Expenditures and funds available under the Research and Marketing Act of 1946, title I, secs. 9 (b) 1 and 9 (b) 2, for the year ended June 30, 1951

Station	Expenditures											Unex- pended bal- ances 1	Funds avail- able 2		
	Personal services	Travel	Trans- porta- tion of things	Com- muni- cation service	Rents and utility services	Print- ing and repro- duction	Other contra- ctual services	Supplies and ma- terials	Equip- ment	Lands and struc- tures (contrac- tual)	Contri- butions to retire- ment			Taxes and assess- ments	Total expend- iture
Alabama.....	\$79,642.43	\$6,056.30	\$1,298.06	\$350.77	\$1,305.30	\$750.69	\$3,310.00	\$17,043.68	\$18,349.95	\$2,041.29		\$12.92	\$130,148.47	\$22,238.63	\$152,387.10
Alaska.....	26,962.96	609.16	11.00	6.40	27.50	150.00	152.97	3,131.87	1,089.02				32,153.80	2,167.87	32,349.55
Arizona.....	21,522.31	2,707.99	48.57	174.16	221.27	10.00	1,074.69	2,000.68	2,113.48	308.53			30,181.68	14,940.05	122,261.91
Arkansas.....	71,952.57	3,512.10	416.61	.65	1,236.34	1,697.42	707.46	11,261.76	15,964.06				93,792.48	107,321.86	93,792.48
California.....	93,792.48														
Colorado.....	28,667.68	1,343.08	273.31	123.43	541.49	254.80	1,266.68	5,729.45	6,736.15		1,082.87		46,018.94	5,796.66	51,815.60
Connecticut: State.....	13,282.58	149.24				47.76	274.85	1,149.70	6,603.46				21,507.59	2,991.68	24,499.27
Storrs.....	13,358.16	390.36						457.93	4,076.40				18,282.85	2,334.75	20,617.60
Delaware.....	26,946.05	1,704.75	9.39	2.12		376.25	306.08	918.16	253.19				30,515.99	2,840.25	33,356.24
Florida.....	41,788.19	2,232.86	114.36		13.08		50.07	1,752.77	3,241.03				49,192.36	11,139.54	60,331.90
Georgia.....	95,205.18	3,787.95	51.60	43.20	833.35	30.77	1,055.68	11,733.29	2,006.08				114,747.10	10,533.36	125,280.46
Hawaii.....	19,261.70	1,133.21	77.88				255.41	2,237.31	4,249.98	200.00			27,415.49	9,207.06	36,622.55
Idaho.....	22,954.03	3,944.70	109.07	68.42	163.25	397.50	196.51	4,586.61	4,997.38	2,097.20			39,514.67	5,018.42	44,563.09
Illinois.....	96,926.66	2,915.84	67.54	21.32	2.06	740.20	1,989.95	14,035.17	9,558.88				128,506.14	15,860.72	144,366.86
Indiana.....	73,416.12	676.08	37.82	1.60	149.19		208.39	11,724.12	5,683.10				91,896.42	5,010.50	96,906.92
Iowa.....	89,887.30												89,887.30		89,887.30
Kansas.....	54,040.71	1,742.93	12.60		11.00		1,382.50	6,682.38	4,091.31	234.94			68,198.37	182.42	68,380.79
Kentucky.....	91,048.49	4,670.81	133.85	941.61		2,437.33	1,558.97	15,428.39	6,388.85			456.00	123,064.30	3,894.46	126,458.76
Louisiana.....	65,286.12	5,666.69	36.42	54.82	16.21	211.57	4,150.74	6,426.63	11,095.86	5,866.52			98,811.58	9,147.30	107,958.88
Maine.....	31,608.48	4,595.25	44.73	108.73	709.37	480.83	1,112.62	5,371.63	374.21				44,405.85	58.84	44,464.69
Maryland.....	35,266.97	1,214.53	1.65	59.74	132.30		695.72	5,147.45	924.37	339.35			43,782.08	6,224.29	50,006.37
Massachusetts.....	21,974.82	1,834.06		10.50			1,000.70	9,599.11	1,331.91				35,751.10	35,751.10	35,751.10
Michigan.....	72,522.89	1,338.95	103.82	285.49		156.17	2,955.27	12,216.85	9,544.14				99,123.58	9,856.64	108,980.22
Minnesota.....	73,837.52	9,822.32	241.42	41.05		1,452.37	2,944.37	7,976.60	7,770.41				104,086.06	22,755.17	126,841.23
Mississippi.....	95,477.06	4,792.00	759.79	629.31	1,797.81	1,610.69	2,369.69	16,412.74	4,515.74				128,364.83	7,981.16	136,345.99
Missouri.....	83,060.67	3,608.48	132.80	183.29	560.48	26.95	6,433.88	9,706.65	4,443.82	175.80	1,359.05		109,691.87	1,015.10	109,691.87
Montana.....	29,376.15	1,124.12	91.93	15.59		8.16	397.79	2,962.93	856.85				35,033.52	38,048.62	36,048.62
Nebraska.....	50,551.90	2,820.74	2.56	378.00			232.07	2,652.16	2,662.33				58,736.47	2,920.25	61,656.72
Nevada.....	12,474.63	605.38	83.98	127.88	291.06		116.64	2,652.16	5,099.76	287.09			21,738.58	21,738.58	21,738.58
New Hampshire.....	25,629.44	86.85	8.48	8.60	6.00	43.05	83.55	909.92	326.09				27,101.98	27,101.98	27,101.98

New Jersey	24,527.60	1,210.15	140.97	7.90	560.72	1,614.42	2,021.81	2,920.71	10,171.03			43,175.31	1,244.36	44,419.67
New Mexico	30,329.73	3,213.32	185.74	99.17	319.06		1,584.25	5,233.25	933.49			41,900.01	43,140.95	45,380.90
New York														
Cornell	49,898.36	3,937.20	100.08	310.81	1,003.96	44.10	4,963.07	12,409.20	11,477.49			84,144.27	15,137.98	99,282.25
State	5,551.79	120.99					2,396.83	1,672.10	1,706.44			11,448.15	1,881.40	13,329.55
North Carolina	116,437.91	3,039.69	258.37	330.50	108.62	79.90	1,240.60	8,897.78	8,682.78	14,122.47		153,218.62	3,896.78	157,115.40
North Dakota	34,206.47	1,128.64	39.16	75.51	528.80	581.82	296.03	2,641.42	1,507.07	939.45		41,914.37	6,788.92	48,703.29
Ohio	105,825.45	3,594.85	76.52	18.00		33.64	1,552.84	5,932.84	2,172.74	38,411.80		157,618.68	55,357.07	212,975.75
Oklahoma	59,328.19	2,470.67		125.08	881.67	14.68	4,242.83	15,396.99	7,396.36	4,994.30		94,850.77	5,956.22	100,806.99
Oregon	30,574.77	3,520.88	87.44	93.74		84.30	397.78	6,665.69	2,000.10			43,424.70	3,087.71	46,512.41
Pennsylvania	86,400.51	6,955.40	48.57	41.95		1,334.25	352.90	18,001.06	18,626.63	27,165.05		158,926.32	14,076.82	173,003.14
Puerto Rico	65,952.06	1,813.48	198.13		700.00	13.00	970.76	16,287.11	7,458.93			93,393.47	13,140.86	106,534.33
Rhode Island	16,677.54	191.04	7.05		240.98	113.65	45.52	2,534.69	1,075.60	93.88		20,949.95	4,360.69	25,310.64
South Carolina	69,167.99	3,052.74	46.10	250.62	911.39	1,951.69	5,175.68	11,100.45	6,789.55	400.00		98,906.21	7,581.51	106,487.72
South Dakota	34,429.75	1,674.40	219.42	15.00		530.19	708.74	7,308.97	1,195.00			46,081.47	9,812.62	55,894.09
Tennessee	97,528.96	2,515.52	140.77	145.89	106.88	100.00	882.29	8,033.51	12,716.67	285.56		122,466.05	3,473.18	125,939.23
Texas	129,571.23	4,949.51	87.01	254.93	209.35	731.71	15,489.41	16,960.55	10,739.10	3,727.06		182,719.56	4,450.59	187,170.45
Utah	15,486.61	400.33	103.81		83.48	105.00	498.39	11,334.30	997.73	503.36		29,513.01	808.56	30,321.57
Vermont	21,853.99	1,013.85	21.21	10.12			443.86	2,589.78	2,003.16	21.17	638.25	28,620.99	4,967.17	33,588.16
Virginia	93,543.52	3,697.66	6.31	212.22	725.72	24.87	3,330.49	6,067.11	3,370.32			110,978.22	11,803.22	122,781.44
Washington	27,688.49	1,908.98	80.15	193.69	3.00	51.34	3,528.43	6,074.55	3,274.42			42,803.35	19,456.64	62,259.99
West Virginia	59,596.92	3,761.60	16.09	24.68	565.61		492.52	6,786.61	6,274.17			77,518.20	27,399.20	104,917.40
Wisconsin	62,066.44	2,818.24	146.82		5.00	703.68	214.91	17,086.12	6,735.59			89,836.80	6.15	89,842.95
Wyoming	19,132.38	2,500.80	29.01	64.91			455.92	1,419.37	2,829.41	46.92		26,478.72	5,374.15	31,852.87
Total	2,813,498.91	134,598.67	6,207.97	5,911.40	14,941.30	18,994.75	87,749.11	384,699.27	274,541.59	101,382.29	6,841.03	494,523,849,860.81	396,947,864,246,808.67	

¹ These unexpended balances by provisions of title I, sec. 9 (a) of the Research and Marketing Act remain available for expenditure during the fiscal year ending June 30, 1952.

² Include allotments from the appropriation for fiscal year 1951 plus unexpended balances of allotments from appropriation for fiscal year 1950.

TABLE 10.—Expenditures and funds available under the Research and Marketing Act of 1946, title I, sec. 9 (b) 3, for the year ended June 30, 1951

Station	Expenditures													Unex- pended balances ¹	Funds available ²
	Personal services	Travel	Trans- porta- tion of things	Commu- nica- tion service	Rents and utility services	Printing and repro- duction	Other contra- ctual services	Supplies and materials	Equip- ment	Lands and structures (contra- ctual)	Contri- butions to retire- ment	Taxes and assess- ment	Total expendi- tures		
Alabama-----	\$15,302.14	\$1,404.25	\$88.56	\$41.57	\$256.25		\$202.14	\$738.83	\$198.52				\$18,532.26	\$1,736.66	\$20,268.99
Alaska-----															
Arizona-----	5,997.06	1,082.77	1.54	5.70		\$1.00	102.66	924.42	242.46	\$129.42			8,487.03	4,440.16	12,927.19
Arkansas-----	24,078.49	2,247.17				5.04	300.00	1,191.13	3,927.42		\$60.00		31,809.25	753.66	32,562.91
California-----	15,272.58	876.36		53.56	224.10	99.94	1,208.71	706.04					18,441.29	3,533.01	21,974.30
Colorado-----	22,308.43	5,169.18	430.03	313.01	436.60	1,432.68	1,546.76	1,955.41	1,704.35		635.00		35,931.45	18,555.89	54,487.34
Connecticut-----															
State-----		898.28													
Storrs-----	13,919.18	705.93	3.35				233.29	388.01	640.37				898.28	101.72	1,000.00
Delaware-----	1,000.00												15,890.13	1,508.62	17,398.75
Florida-----	6,202.00	2,561.06	3.29				23.40	544.18	30.00				9,363.93	4,688.26	1,000.00
Georgia-----	30,709.98	2,920.69	75.04	.78	6.00	55.09	449.27	10,081.85	1,211.92				45,510.62	9,093.24	54,603.86
Hawaii-----															
Idaho-----	14,153.22	299.58	68.81	163.56		824.58	41.49	5,809.03	1.00				21,361.27	69.37	21,430.64
Illinois-----	15,792.34	342.57	54.23	30.35	30.35	301.29	791.11	4,511.01	5,273.13				27,637.79	11,253.45	38,891.24
Indiana-----	4,846.50	4,846.50	142.61	14.23	427.09		417.22	30,706.94	602.65	4,282.85			64,537.81	5,931.17	70,468.98
Iowa-----	30,653.35	8,205.65	73.89	245.55		2,757.29		16,103.15	2,886.95	18,969.62			79,895.45	2,497.96	82,393.41
Kansas-----	10,859.99	1,475.45	60.03		20.00		540.64	4,800.40	2,371.73				20,128.24	23	20,128.47
Kentucky-----	7,665.65	638.29	4.00	10.54				120.34					8,438.82	52.80	8,491.62
Louisiana-----	14,372.42	1,059.32	15.84	43.82	78.00	440.04	751.87	2,112.53	1,880.17	6,288.15			27,012.16	4,025.16	31,067.32
Maine-----	20,655.34	867.83	76.58	153.25	379.00		522.62	927.50	267.88				23,850.00		23,850.00
Maryland-----	6,961.25	2,268.65	22.18	11.00	32.62	27.59	1,046.62	5,135.82	2,064.51	87.40			17,657.64	1,067.56	18,725.20
Massachusetts-----	12,841.68							10.72					12,841.68	1,069.25	13,965.40
Michigan-----	22,362.83	2,728.16	42.32	26.10		80.01	1,561.02	414.07	3,012.25				30,226.76	8,940.86	39,167.62
Minnesota-----	20,711.55	4,168.82	12.75	29.06	70.49	1,157.47	1,630.03	7,781.53	3,781.13				33,282.68	5,791.03	39,073.71
Mississippi-----	30,730.51	4,972.36	272.40	103.54	177.85	354.54	548.18	2,956.08	620.14				40,733.60	7,268.20	48,003.80
Missouri-----	13,868.40	1,519.64	7.82	68.18	21.53		426.54	3,848.91	682.12	400.00	60.00		20,903.14		20,903.14
Montana-----	13,441.88	2,945.58	39.94			29.25	497.58	676.96	116.42				17,747.61	2,922.68	20,670.28
Nebraska-----	16,950.60	1,108.34			4.18		4.18	1,805.28	173.95	558.73			20,631.08	118.16	20,749.24
Nevada-----	2,997.00	154.12	5.74				49.98	1,043.16	900.00				5,150.00		5,150.00
New Hampshire-----	2,900.00				395.00		186.72	819.28					4,300.00		4,300.00

New Jersey	21,068.57	1,163.43	72.00	147.91	1,307.69	327.10	24,086.70	5,878.56	29,965.26
New Mexico	12,770.33	406.33	27.12	1,022.52	2,873.52	2,464.78	19,601.11	8.93	19,610.04
New York:									
Cortell	38,761.62	3,114.39	20.60	212.47	5,888.34	4,434.43	57,008.31	10,613.09	67,621.40
State	30,949.33	7,467.67	9.93	2,078.38	2,353.61	1,240.07	44,578.82	6,033.83	50,612.65
North Carolina									
North Dakota	3,376.83	2,514.82	43.60	318.20	152.20	1,435.44	6,880.25	932.31	7,812.56
Ohio	22,025.44	869.90	79.90	225.65	6,010.46	1,606.00	25,637.20	544.55	26,181.85
Oklahoma	1,825.45	706.63	40.43	782.48	2,985.19	976.11	10,739.79	7,977.48	18,717.27
Oregon	30,098.65	2,049.39	6.87	22.52	2,225.93	3,062.69	37,091.25	5,833.40	42,924.65
Pennsylvania	16,973.02	1,368.36		28.92	7		31,504.66	14,706.73	46,211.39
Puerto Rico	3,492.53				7.47		3,500.00		3,500.00
Rhode Island	20,032.81	652.51	4.24	3.10	2,249.66	1,486.38	24,451.45	1,196.57	25,648.02
South Carolina	23,636.89	1,665.66	42.82	484.13	1,759.65	94.15	27,876.79	2,030.01	29,906.80
South Dakota	9,945.23	386.97	21.94	59.64	3,033.04	2,634.63	16,102.05	2,196.62	18,298.67
Tennessee	21,726.61	2,340.70	3.75	100.35	1,817.55	3,101.76	31,821.07	2,160.74	33,981.81
Texas	40,117.52	3,567.36	7.35	134.66	6,713.29	5,149.68	61,325.59	890.45	62,216.04
Utah	41,024.85	6,807.17	466.63	4,463.74	11,507.37	4,631.97	69,594.31	21,138.02	91,032.33
Vermont	1,888.01	630.52	2.74	74.89	2,553.61	594.07	6,719.36	302.52	7,021.88
Virginia	9,219.75	1,361.56	1.50	1,190.56	169.30	318.61	12,375.00	3,000.00	15,375.00
Washington	20,778.50	2,047.11	3.32	32.71	7,539.50	1,007.87	32,385.87	8,899.50	41,285.37
West Virginia	25,704.94	2,511.18	8.00	122.82	1,823.01	4,936.76	35,782.56	5,719.53	41,502.09
Wisconsin	17,870.81	5,819.63	208.26	379.63	8,670.33	2,460.16	37,933.26	19,172.08	57,105.34
Wyoming	8,560.30	2,545.80	19.13	502.50	917.80	158.66	12,768.21	3,160.97	15,929.18
Total	837,703.58	105,463.64	2,439.18	32,575.57	172,904.45	74,950.79	1,292,350.05	217,815.09	1,510,165.14

¹ These unexpended balances by provisions of title I, sec. 9 (a) of the Research and Marketing Act remain available for expenditure during the fiscal year ending June 30, 1952.

² Include allotments from the appropriation for fiscal year 1951 plus unexpended balances of allotments from appropriation for fiscal year 1950.

TABLE 11.—Expenditures from non-Federal funds for the year ended June 30, 1951

Station	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total	Unexpended balance
Alabama	\$549,081.50	\$29,435.43	\$6,994.10	\$5,411.98	\$19,147.50	\$4,282.67	\$75,837.94	\$846,851.38	\$100,789.78	\$36,801.75			\$1,174,613.83	\$286,301.31
Alaska	80,387.95	720.37	2,018.86	112.11	513.50	1,421.45	7,854.93	9,099.72	8,064.30	3,573.95		\$531.13	113,998.27	27,300.14
Arizona	264,014.37	793.93	713.65	3,208.55	1,831.87	7,360.60	12,956.90	50,070.79	14,641.85	7,075.82		1,752.41	371,440.74	
Arkansas	318,512.51	15,453.03	2,026.06	3,171.50	15,608.26	43,358.25	43,358.25	140,090.70	42,570.23		\$3,015.08		594,328.52	103,989.06
California	3,610,517.48	165,505.52	8,440.33	52,333.85	36,936.46	93,449.12	166,735.55	395,887.19	214,002.77				4,743,808.17	233,342.35
Colorado	275,760.84	14,875.82	3,200.49	5,193.60	18,478.44	9,985.24	17,300.65	117,876.12	49,385.00	468.50	6,375.02		518,900.52	130,980.76
Connecticut														
State	264,720.84	2,721.41	166.89	2,749.83	6,330.49	6,092.19	11,328.48	24,028.78	17,795.03	2,208.32			338,142.26	38,866.31
Storrs	250,339.92	2,011.10	103.85	8,45	1,437.11	4,834.24	2,363.03	45,178.48	16,891.87	70,000.00			394,007.95	37,534.25
Delaware	125,460.76	4,172.38	399.95	3,770.54	4,231.63	553.61	5,296.90	79,094.25	8,119.90	110.00			231,209.92	23,833.14
Florida	1,667,804.42	68,287.58	5,766.69	16,121.55	45,978.94	13,735.15	51,677.12	424,242.68	168,948.47	1,448.45			2,461,011.05	833,901.93
Georgia	174,367.38	10,593.29	879.53	3,661.85	11,267.46	8,133.36	14,463.73	104,785.20	8,603.81	2,552.86			339,608.47	97,251.13
Hawaii	455,774.96	12,850.20	1,830.90	2,839.46	8,979.29	10,652.78	25,221.28	59,540.16	63,647.74	30,640.97			683,950.74	5,020.30
Idaho	282,036.30	13,098.16	5,255.00	8,605.00	11,120.00	2,975.00	2,825.00	63,606.04	63,929.42	121,306.42			574,756.34	70,346.71
Illinois	1,102,797.63	90,000.00	27,000.00	27,000.00	55,000.00	55,000.00		342,120.08	70,600.36	7,428.91			1,800,565.30	
Indiana	965,158.16	39,681.41	8,416.33	12,447.99	24,004.74	93,808.01	101,900.52	454,599.66	152,385.22	167,329.49			2,019,731.53	515,261.83
Iowa	823,693.64	49,223.73	3,097.23	6,444.78	9,382.95	27,154.92		561,433.81	108,673.11	94,555.46	60,180.13		1,734,456.81	212,598.07
Kansas	389,120.35	12,850.32	8,298.29	4,921.14	9,382.95	1,302.00	20,219.41	126,744.55	79,580.50	29,387.46			687,866.97	107,574.65
Kentucky	427,156.15	11,585.75	600.77	5,904.06	14,289.83	3,202.20	38,319.33	91,959.95	37,232.38			3,172.15	633,813.65	
Louisiana	769,674.16	36,598.93	2,566.75	4,515.04	11,391.32	1,632.20	68,584.79	218,268.30	45,125.31	57,428.88			1,215,800.68	
Maine	156,421.28	12,213.04	805.35	2,280.39	6,269.51	4,783.96	13,882.17	29,121.33	8,871.03	10,026.04			244,674.10	34,731.92
Maryland	242,651.29	11,176.13	405.02	1,436.53	1,367.21	3,724.14	18,482.08	106,815.82	35,543.19	2,586.91			424,548.32	110,776.77
Massachusetts	389,739.61	8,548.53	351.57	3,379.74	1,041.50	4,571.78	1,438.37	34,700.28	16,908.01				400,739.39	23,446.73
Michigan	892,169.65	43,377.31	2,828.46	3,464.52	6,127.01	17,966.99	69,867.05	148,769.81	91,084.74				1,275,655.54	121,641.32
Minnesota	1,102,797.63	20,550.16	5,209.45	11,436.34	25,170.34	11,514.81	118,628.40	287,572.18	83,676.50	29,429.80			1,695,985.61	
Mississippi	561,066.89	14,601.60	8,257.99	5,969.02	19,032.83	8,003.83	64,160.21	365,478.38	159,020.07	23,595.44			1,229,186.26	232,015.21
Missouri	284,894.14	16,035.10	2,946.22	2,148.88	12,449.93	12,434.75	38,988.61	113,882.38	51,734.41				542,818.58	259,218.28
Montana	391,343.87	9,030.99	1,949.47	3,480.64	34,691.30	4,741.39	28,485.93	161,974.76	50,179.72	47,073.44	14,557.00		748,308.51	190,438.43
Nebraska	485,666.00	32,515.21	6,657.90	3,615.06	10,971.66	8,936.66	3,379.78	364,090.82	137,943.13	4,169.23			1,037,946.05	62,277.92
Nevada	25,631.39	1,754.69	506.35	811.07	2,163.99	9,960.16	2,486.90	7,597.95	16,160.66	540.25			59,006.58	37,213.90
New Hampshire	39,551.50	4,120.61	101.43	134.06		1,425.95	2,013.00	4,465.38	4,252.77				56,066.70	739.65
New Jersey	738,267.71	26,805.55	1,870.04	14,398.68	35,671.83	10,415.59	86,316.94	143,175.81	42,792.16		177.19		1,099,891.50	9,523.72
New Mexico	138,636.61	2,647.88	663.00	752.16	5,875.83	3,971.27	10,343.61	31,662.76	21,675.83	6,591.74	6,348.43		229,169.12	78,782.93
New York														
State	1,867,894.67	34,563.02	4,161.13	20,937.29	111,036.27	11,712.27	52,380.22	261,796.89	104,556.49	2,134.43			2,470,672.68	
Cornell	654,895.35	8,512.65	2,254.09	4,146.09	12,329.59	11,001.36	14,451.21	71,951.21	36,355.41				815,907.34	
North Carolina	905,447.37	29,737.59	2,892.86	9,296.76	17,087.47	21,496.35	100,798.93	141,115.52	79,794.29	47,412.90			1,355,080.04	

North Dakota	299,658.48	19,664.19	2,320.21	2,536.21	25,261.25	19,688.47	21,331.06	119,418.98	67,484.86	96,491.61	5,006.00	678,861.32	86,043.28
Ohio	631,225.32	14,073.36	5,356.12	8,106.19	20,962.63	8,120.12	37,923.65	307,129.33	59,663.55	518,572.20	1,350.24	1,611,132.47	411,992.55
Oklahoma	559,400.76	31,324.64	2,780.75	2,636.24	19,794.14	16,364.03	29,126.01	214,008.17	161,535.37	389,609.89	1,350.24	1,127,939.24	108,126.71
Oregon	967,990.24	51,582.72	6,172.78	11,419.64	18,518.33	14,431.58	42,361.30	228,622.27	104,237.94	47,500.00	44,867.46	1,537,914.26	86,433.27
Pennsylvania	706,480.64	27,790.24	831.31	2,826.95	7,674.00	9,398.90	14,361.24	153,378.09	29,226.55	38,827.05	29,226.55	991,794.97	86,433.27
Puerto Rico	393,048.38	6,162.10	2,051.18	2,702.49	14,411.36	12,705.11	26,092.60	76,870.04	72,043.40	52,969.84	29,283.31	688,339.81	203,024.98
Rhode Island	77,305.72	1,597.20	51.68	306.39	13.36	1,150.87	1,520.99	15,439.80	5,504.89	320.00	5,504.89	103,211.50	23,629.51
South Carolina	346,561.43	10,562.22	93.34	1,618.99	3,275.60	1,004.47	14,638.78	89,268.45	26,987.25	100,000.00	100,000.00	594,010.53	35,775.76
South Dakota	182,395.71	5,470.81	892.64	930.98	2,082.10	2,186.69	13,155.82	84,901.87	21,599.65	12,531.11	21,599.65	313,616.27	38,877.30
Tennessee	323,631.21	8,108.51	2,611.38	4,978.41	4,935.49	5,767.05	16,916.33	188,003.30	61,194.23	12,531.11	12,531.11	628,677.04	62,877.04
Texas	1,183,344.77	37,060.21	2,626.62	16,615.62	31,671.30	12,722.41	303,518.24	296,201.06	304,349.50	130,842.92	24,641.65	2,393,281.82	767,124.05
Utah	239,916.82	12,832.03	2,991.54	2,952.09	10,733.01	14,124.63	7,132.18	80,859.63	42,894.53	15,211.57	1,060.79	429,668.03	124,398.01
Vermont	2,417.29	308.17	308.17	548.75	5,425.36	732.73	6,386.42	9,374.99	4,801.49	195.12	1,060.79	78,553.96	14,956.78
Virginia	421,578.07	27,323.83	1,643.57	8,504.64	9,341.83	4,296.26	19,936.45	87,182.26	39,396.48	84,452.95	84,452.95	703,655.34	86,182.95
Washington	1,152,301.88	57,096.24	10,028.52	9,697.15	19,317.23	14,976.18	53,019.63	304,146.16	140,528.57	7,968.35	41,110.14	1,810,010.03	1,810,010.03
West Virginia	160,530.60	5,487.00	883.39	2,016.40	9,607.30	2,327.45	33,552.93	87,245.54	34,185.75	130,394.21	130,394.21	466,230.69	111,501.07
Wisconsin	1,461,707.56	21,656.21	2,862.40	2,142.60	6,729.15	9,362.61	50,630.14	349,216.89	79,377.50	12,692.51	12,692.51	1,983,085.00	390,812.81
Wyoming	167,028.10	17,225.77	5,587.46	5,587.46	6,062.06	4,174.38	13,325.37	88,517.95	76,199.21	12,692.51	12,692.51	390,812.81	72,629.07
Total	31,159,117.35	1,222,498.00	147,091.98	342,238.80	758,051.56	615,431.81	2,005,860.74	8,709,803.90	3,529,287.18	2,159,011.49	237,982.04	50,972,123.13	6,128,601.11

TABLE 12.—Summary by States of expenditures of the experiment stations for the year ended June 30, 1951

Station	Federal-grant funds						Contractual Federal funds, Research and Marketing, title II	Non-Federal funds	Grand total	
	Hatch	Adams	Purnell	Bankhead-Jones	Research and Marketing, title I					Total
					Secs. 9(b)1-9(b)2	Sec. 9(b)3				
Alabama.....	\$15,000.00	\$15,000.00	\$60,000.00	\$96,152.81	\$130,148.47	\$18,532.26	\$334,833.54	\$1,174,613.83	\$1,519,086.32	
Alaska.....	15,000.00	7,500.00	30,000.00	2,627.86	32,163.80	---	87,281.66	113,998.27	201,279.93	
Arizona.....	15,000.00	15,000.00	60,000.00	15,499.36	30,181.68	8,487.03	144,168.07	371,440.74	515,608.81	
Arkansas.....	15,000.00	15,000.00	60,000.00	74,312.76	107,321.86	31,809.25	303,443.87	594,328.52	897,772.39	
California.....	15,000.00	15,000.00	60,000.00	95,542.61	93,792.48	18,441.29	297,776.38	4,743,808.17	5,049,894.03	
Colorado.....	15,000.00	15,000.00	60,000.00	26,055.98	46,018.94	35,931.45	198,006.37	518,900.52	716,906.89	
Connecticut: State.....	7,500.00	7,500.00	30,000.00	13,031.04	21,507.59	898.28	80,486.91	338,142.26	418,629.17	
Delaware.....	7,499.94	7,500.00	29,999.21	13,128.62	18,282.85	15,890.13	92,300.75	7,267.36	493,636.06	
Florida.....	14,824.93	14,847.92	59,994.46	6,054.94	30,515.99	1,000.00	127,238.24	231,209.92	358,448.16	
Georgia.....	15,000.00	15,000.00	60,000.00	40,579.22	49,192.36	9,363.93	189,135.51	9,711.83	2,662,858.39	
Hawaii.....	15,000.00	15,000.00	60,000.00	101,476.80	114,747.10	45,510.62	351,734.52	339,608.47	715,221.60	
Idaho.....	15,000.00	15,000.00	60,000.00	10,269.39	27,415.49	---	127,684.88	663,990.74	799,776.04	
Illinois.....	15,000.00	15,000.00	60,000.00	16,589.81	39,514.67	21,361.27	167,465.75	574,756.34	742,222.09	
Indiana.....	15,000.00	15,000.00	60,000.00	100,946.87	128,506.14	27,637.79	347,090.80	1,860,565.30	2,214,448.53	
Iowa.....	15,000.00	15,000.00	60,000.00	73,383.88	91,896.42	64,537.81	319,818.11	26,048.26	2,365,597.90	
Kansas.....	15,000.00	15,000.00	60,000.00	74,752.37	89,887.30	79,895.45	334,535.12	24,229.15	2,093,221.08	
Kentucky.....	15,000.00	15,000.00	60,000.00	57,178.54	68,198.37	20,128.24	235,505.15	12,096.76	935,468.88	
Louisiana.....	15,000.00	15,000.00	60,000.00	95,122.25	123,064.30	8,438.82	316,625.37	633,813.65	950,439.02	
Maine.....	15,000.00	15,000.00	60,000.00	65,919.96	98,811.58	27,042.16	281,773.70	---	1,497,574.38	
Maryland.....	15,000.00	15,000.00	60,000.00	24,124.05	44,405.85	23,860.00	182,379.90	7,846.39	434,900.39	
Massachusetts.....	14,998.74	15,000.00	60,000.00	35,303.01	43,782.08	17,657.64	186,741.47	424,548.32	617,296.56	
Michigan.....	15,000.00	15,000.00	60,000.00	21,787.39	35,751.10	12,896.15	190,434.64	490,739.39	621,174.03	
Minnesota.....	15,000.00	15,000.00	60,000.00	85,827.73	99,123.58	30,226.76	305,178.07	1,275,655.54	1,618,545.54	
Mississippi.....	15,000.00	15,000.00	60,000.00	66,813.91	104,086.06	33,282.68	294,182.65	1,695,985.61	1,990,168.26	
Missouri.....	15,000.00	15,000.00	60,000.00	84,569.98	128,364.83	40,735.60	343,670.41	27,194.68	1,600,051.35	
Montana.....	15,000.00	15,000.00	60,000.00	89,383.63	109,691.87	20,903.14	309,978.64	3,400.00	856,197.22	
Nebraska.....	15,000.00	15,000.00	60,000.00	17,871.46	35,033.52	17,747.61	160,652.59	542,818.58	748,308.51	
Nevada.....	15,000.00	15,000.00	60,000.00	44,233.72	58,736.47	20,631.08	213,601.27	1,057,946.05	1,274,304.72	
New Hampshire.....	15,000.00	15,000.00	60,000.00	3,190.40	21,738.58	5,150.00	120,078.98	59,006.58	1,179,085.56	
				9,925.30	27,101.98	4,300.00	131,327.28	1,229,186.26	1,600,051.35	
								3,400.00	856,197.22	
								2,757.40	908,961.10	
								---	1,057,946.05	
								---	59,006.58	
								---	187,393.98	

New Jersey.....	15,000.00	15,000.00	36,470.37	43,175.31	24,086.70	193,732.38	4,266.00	1,099,891.50	1,297,889.88
New Mexico.....	15,000.00	15,000.00	16,935.36	41,900.01	19,601.11	168,436.48	-----	229,169.12	397,605.60
New York:									
Cornell.....	13,499.48	13,500.00	99,201.63	84,144.27	57,008.31	321,353.53	4,138.10	2,470,672.68	2,796,154.31
State.....	1,499.98	1,500.00	10,991.73	11,448.15	-----	31,439.86	10,571.70	815,907.34	2,557,918.90
North Carolina.....	15,000.00	15,000.00	123,706.51	153,218.62	44,578.82	411,563.95	5,337.07	1,355,080.04	1,772,181.06
North Dakota.....	15,000.00	15,000.00	28,147.42	41,914.37	6,880.25	166,942.04	-----	678,861.32	845,803.36
Ohio.....	15,000.00	15,000.00	109,337.26	157,618.68	25,637.27	382,593.14	11,211.48	1,611,132.47	2,004,937.09
Oklahoma.....	15,000.00	15,000.00	78,367.16	94,850.77	10,739.79	273,957.72	1,729.60	1,127,939.24	1,403,626.56
Oregon.....	15,000.00	15,000.00	26,588.72	43,424.70	37,091.25	197,104.67	3,557.77	1,537,914.26	1,738,576.70
Pennsylvania.....	15,000.00	15,000.00	157,876.48	158,926.32	31,504.66	438,307.46	-----	991,794.97	1,430,102.43
Puerto Rico.....	15,000.00	15,000.00	62,082.14	93,393.47	3,500.00	248,975.61	6,032.33	688,339.81	913,347.75
Rhode Island.....	15,000.00	15,000.00	2,857.19	20,949.95	24,451.45	138,258.59	-----	103,211.50	241,470.09
South Carolina.....	15,000.00	15,000.00	69,224.19	98,906.21	27,876.79	286,007.19	-----	594,010.53	880,017.72
South Dakota.....	15,000.00	15,000.00	27,733.01	46,081.47	16,102.65	179,916.53	-----	313,616.27	493,532.80
Tennessee.....	15,000.00	15,000.00	89,992.09	122,466.05	31,821.07	334,279.21	2,534.32	628,677.04	965,490.77
Texas.....	15,000.00	15,000.00	173,212.42	182,719.86	61,325.59	507,257.82	26,151.14	2,393,281.82	2,926,690.78
Utah.....	15,000.00	15,000.00	12,170.15	29,513.01	69,894.31	201,577.47	-----	429,668.03	631,245.50
Vermont.....	15,000.00	15,000.00	12,078.01	28,620.99	6,719.36	137,418.36	-----	78,553.95	215,972.32
Virginia.....	15,000.00	15,000.00	82,941.86	110,978.22	12,375.00	296,295.08	-----	703,655.34	999,930.42
Washington.....	15,000.00	15,000.00	38,673.22	42,803.35	32,385.87	203,862.44	9,150.68	1,810,010.03	2,023,023.15
West Virginia.....	15,000.00	15,000.00	65,169.05	77,518.20	35,782.56	268,469.81	2,500.00	466,230.69	737,200.50
Wisconsin.....	15,000.00	15,000.00	70,152.59	89,836.80	37,933.26	287,922.65	1,268.22	1,983,685.00	2,272,875.87
Wyoming.....	15,000.00	15,000.00	7,829.36	26,478.72	12,768.21	137,076.29	-----	390,812.81	527,889.10
Total.....	704,823.07	757,347.92	2,863,503.57	3,849,860.81	1,292,350.65	12,557,878.88	309,679.03	50,972,123.13	63,839,681.04

TABLE 13.—Summary by classification of expenditures of the experiment stations for the year ended June 30, 1951

Account	Hatch Act	Adams Act	Purnell Act	Bankhead-Jones Act	Research and Marketing Act, title I		Total	Contractual Federal funds, Research, and Marketing Act, title II	Non-Federal funds	Grand total
					Secs. 9 (b) 1 and 9 (b) 2	Sec. 9 (b) 3				
01 Personal services	\$617,620.41	\$667,602.24	\$2,527,228.99	\$2,325,189.99	\$2,813,498.91	\$837,703.58	\$9,788,844.12	\$230,144.93	\$31,159,117.39	\$41,178,106.44
02 Travel	24,115.47	7,702.85	60,760.65	45,528.00	134,598.67	105,463.64	378,169.28	21,953.92	1,222,498.00	1,622,621.20
03 Transportation of things	883.27	481.49	2,957.97	2,957.65	6,207.97	2,439.18	15,757.53	206.45	147,091.98	163,055.96
04 Communication services	6,328.40	320.58	3,073.15	3,304.28	5,911.40	2,857.98	21,795.79	634.53	342,238.80	364,669.12
05 Rents and utility services	3,119.82	2,151.92	12,155.30	9,402.35	14,941.30	4,749.49	46,520.18	591.93	758,051.56	805,163.67
06 Printing and reproduction	35,626.79		18,155.47	18,224.68	18,994.75	14,989.19	105,990.88	717.47	645,431.81	752,140.16
07 Other contractual services	8,705.20	4,505.54	31,588.89	36,570.89	87,749.11	32,575.57	201,695.20	7,616.81	2,005,890.74	2,215,172.75
08 Supplies and materials	34,736.49	47,196.44	235,671.97	284,134.72	384,699.27	172,964.45	1,159,403.34	22,379.30	8,709,803.90	9,891,586.54
09 Equipment	30,408.18	23,486.88	126,042.51	116,534.89	274,541.59	74,950.79	645,984.84	24,959.09	3,523,287.18	4,200,231.11
10 Lands and structures (contractual)	639.07	1,116.43	2,858.83	12,924.09	101,382.29	42,254.82	161,175.53	474.60	2,189,011.49	2,320,661.62
11 Contributions to retirement	2,534.50	2,779.59	9,283.02	8,569.12	6,841.03	1,397.71	31,404.97		237,982.04	269,387.01
15 Taxes and assessments	105.47	3.96	386.71	142.91	494.52	3.65	1,137.22		55,748.24	56,885.46
Total	764,823.07	757,347.92	3,029,993.46	2,863,503.57	3,849,860.81	1,292,350.05	12,557,878.88	309,679.03	50,972,123.13	63,839,681.04

TABLE 14.—Expenditures and allotments under the Research and Marketing Act of 1946, title II, for the year ended June 30, 1951

STATISTICS

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Station	Expenditures										Unex- pended balance	Funds available ¹
	Personal services	Travel	Trans- porta- tion of things	Commu- nication service	Rents and utility services	Print- ing and repro- duction	Other contra- actual ser- vices	Supplies and ma- terials	Equip- ment	Lands and struc- tures (contra- actual)	Total expendi- tures	
Alabama.....	\$4,051.37	\$352.95	\$5.77	\$16.65	\$53.40		\$122.81	\$1,532.42	\$3,503.58		\$9,638.95	\$10,387.54
California.....	8,309.48										8,309.48	8,400.00
Connecticut.....	6,669.96	597.40									7,267.36	7,267.78
Florida.....	8,726.36	983.47									9,711.83	15,752.95
Georgia.....	19,052.85	2,103.82		.05	211.20	\$7.12	107.46	1,316.39	479.72		23,878.61	28,936.82
Hawaii.....	5,384.31	2,591.68		31.20			11.21	118.55	3.47		8,140.42	15,120.23
Illinois.....	6,705.82	84.61						2.00			6,979.81	10,800.00
Indiana.....	20,807.83	513.36		4.97			288.10	1,964.07	2,469.93		26,048.26	29,788.80
Iowa.....	19,160.28	176.32	30.28	17.74		49.01		2,584.63	2,210.85		24,229.15	24,532.50
Kansas.....	10,436.41	1,111.20					170.15	166.15	212.85		12,096.76	12,116.47
Maine.....	3,796.06	562.85	4.99	30.37			1,255.63	1,696.49	500.00		7,846.39	7,846.39
Maryland.....	5,280.06	622.66						74.05	30.00		6,006.77	7,102.15
Michigan.....	29,049.63	3,239.36	3.08	88.64		630.69	2,135.20	320.09	1,345.24		37,711.93	61,855.36
Mississippi.....	10,722.36	1,821.55	15.73	191.91	327.33		221.55	3,054.07	4,840.18		27,194.68	41,565.40
Missouri.....	1,030.63	521.21	4.46				216.20	512.32	515.18		3,400.00	3,400.00
Nebraska.....	2,757.40										2,757.40	5,000.00
New Jersey.....	3,838.24	30.24					64.89	227.50	105.13		4,268.00	10,223.20
New York.....	3,193.37	223.07					25.00	299.26	397.40		4,138.10	6,316.10
Cornell.....	3,951.96	238.28	29.81				2,224.98	1,590.65	2,536.02		10,571.70	10,770.97
State.....												
North Carolina.....	4,178.44	773.00					20.50	565.13			5,537.07	5,600.00
Ohio.....	5,720.28	1,671.25						2,419.95	1,400.00		11,211.48	11,211.48
Oklahoma.....	1,515.00	77.33					7.45		129.82		1,729.60	1,729.60
Oregon.....	3,513.52	6.40		1.95				2.35	33.55		3,557.77	3,559.90
Puerto Rico.....	1,710.72	833.61	106.65					1,121.52	2,259.83		5,541.21	11,573.54
Tennessee.....	1,879.92	85.65		241.35				131.25	196.35		2,534.52	10,474.87
Texas.....	19,627.41	1,425.03				27.00	732.94	2,114.21	1,749.95	\$474.60	26,151.14	27,283.99
Washington.....	8,893.56	16.35		9.70		3.65	12.74	214.68			9,150.68	11,037.81
West Virginia.....	1,459.57	1,040.43									2,500.00	2,500.00
Wisconsin.....	622.13	248.84	5.68					351.57	40.00		1,268.22	9,456.88
Total.....	230,144.93	21,953.92	206.45	634.53	591.93	717.47	7,616.81	22,379.30	24,959.09	474.60	309,679.03	411,610.73

¹ Include allotments from the appropriation for fiscal year 1951 plus unexpended balances of allotments from appropriation for fiscal year 1950.

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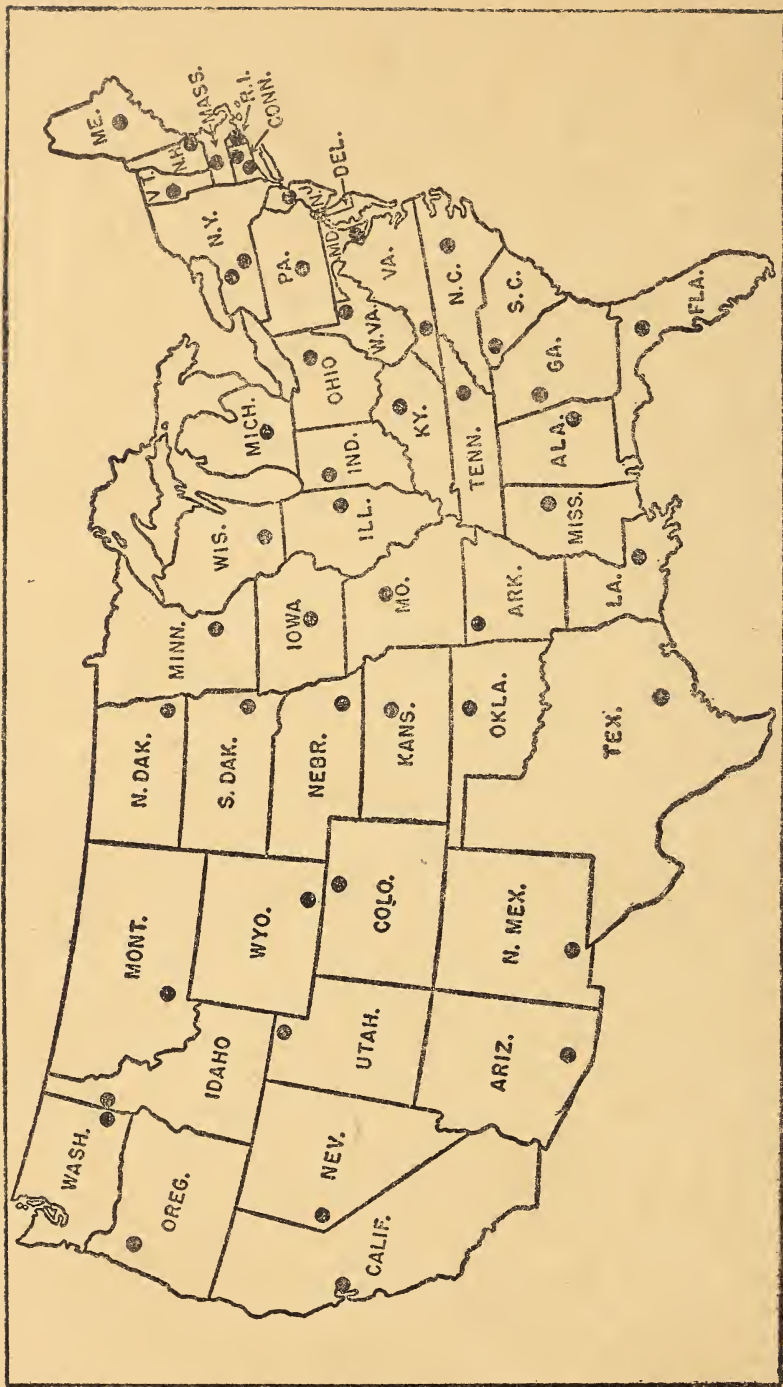
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